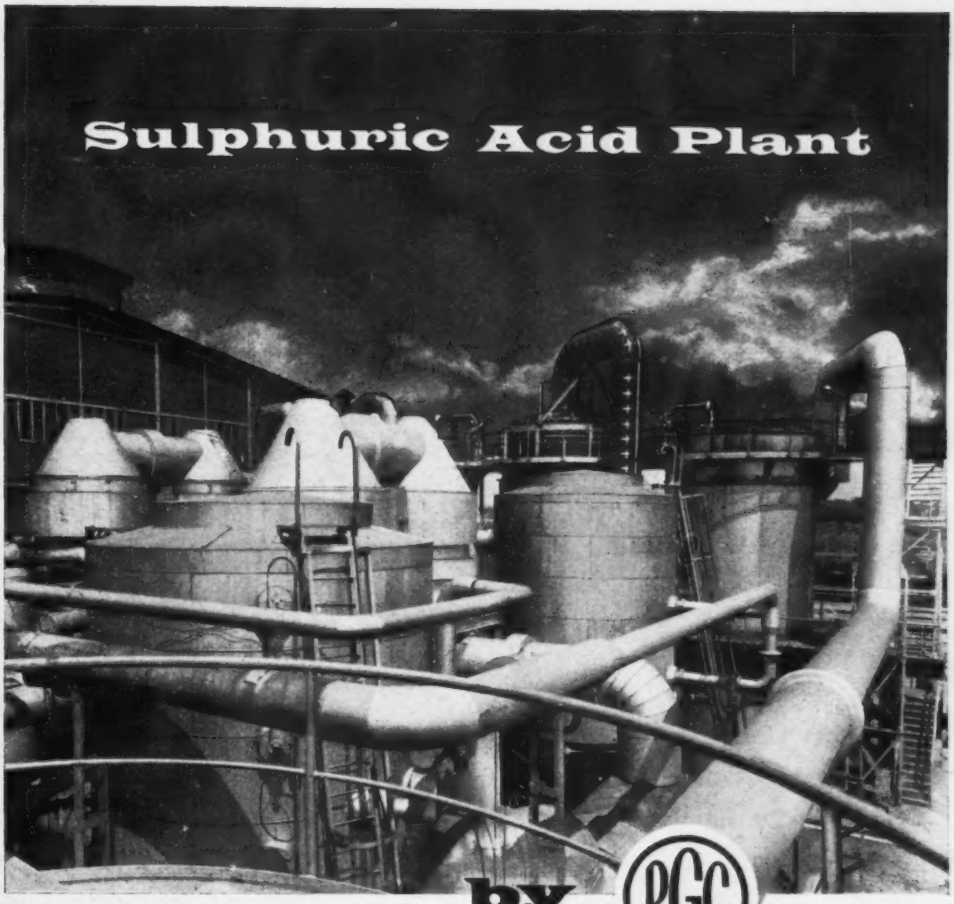

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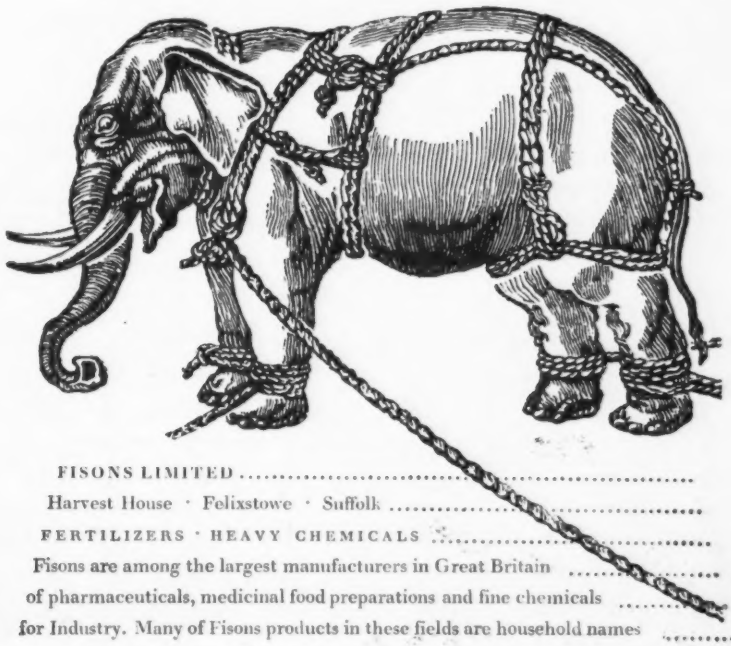

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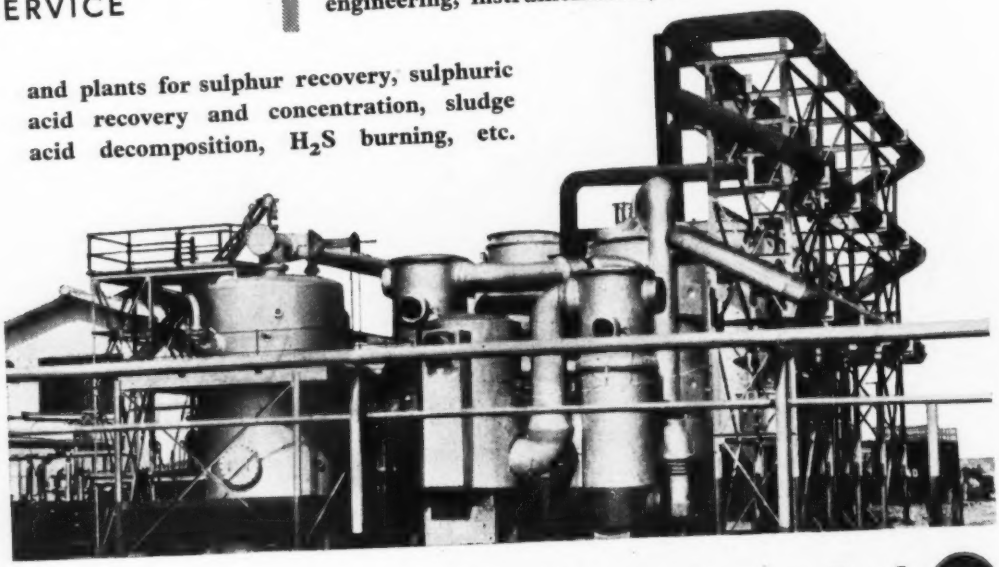

Sulphuric acid plants by ***Simon-Carves Ltd***

SIMON ENGINEERING GROUP

STOCKPORT, ENGLAND

OVERSEAS COMPANIES | *Simon-Carves(Africa)(Pty) Ltd: Johannesburg* *Simon-Carves(Australia)Pty Ltd: Botany, N.S.W.*

SC 126

QUARTERLY BULLETIN No. 9

JUNE 1955

ISSUED BY

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FOREWORD

We greatly regret any inconvenience that may have been caused to subscribers and advertisers by the delay in the issue of the last (No. 8, March, 1955) *Quarterly Bulletin*. Indirectly this was due to the London newspaper printers' strike, which resulted in an overload of urgent work on other printers, and consequently delayed the printing of the *Bulletin*.

Suggestions from subscribers as to any wider scope of the *Bulletin* articles, together with any criticisms or suggestions on the subject of its present contents, would be most welcome, and it is hoped that readers will not hesitate to correspond with us in this connection.

June, 1955.

Review

THE sulphur-using industries of the **British Commonwealth of Nations** account for about 19% of current world consumption, and although still dependent on outside sources of supply for more than one-half of their requirements, the expansion of production and use of indigenous resources has substantially reduced this dependence in the past six years. Lacking commercially exploitable deposits of native sulphur, the Commonwealth nevertheless accounts for a substantial proportion of world reserves of sulphur in other forms, notably metal sulphides, including pyrites and pyrrhotite, anhydrite, and sulphur in natural gas. The main impetus to the expansion of acid facilities based on raw materials other than brimstone, notably in Canada, Australia and the U.K., has its origin in the sulphur crisis of 1951/2. Most of these projects were only completed when world supplies of low-cost elemental sulphur were once more adequate so that their operations, desirable from the point of view of using national resources, are in many cases at a disadvantage compared with plants based on brimstone to the extent that in Australia their operations are supported by a Government subsidy.

In the immediate future, the further development and use of indigenous sulphur resources is expected to be checked with the exception of such integrated developments as the pyrites/uranium industry in the Union of South Africa, the use of sulphur in nickel, lead or zinc smelter gases in Canada, and of course recovery, in the form of H_2S or elemental sulphur, from natural and industrial gases. In view of the anticipated growth of sulphur usage of about 5% per annum, and since its individual markets already take up about two-thirds of all exports of brimstone, the British Commonwealth will tend to assume during the next few years even greater importance in the world sulphur trade.

In the **United States** production of native and recovered sulphur during the first quarter of 1955 totalled 1,374,950 tons, 7½% less than during the preceding quarter and 6% less than during the corresponding period of 1954. At the same time, the high level of industrial activity in the U.S.A. and buoyant exports, caused apparent consumption to rise to 1,497,150 tons, the third highest quarterly total on record. The reduction of stocks of native and recovered sulphur to a level about 155,000 tons below that at the end of March, 1954, occurring at a time when substantial additions were made to productive capacity, is believed to be due in part to the deliberate policy of some producers.

The annual report of the **Texas Gulf Sulphur Company** discloses that 1954 has been the most successful financial year in the company's history. Frasch sulphur production from the three operating domes—Boling, Moss Bluff and Spindletop—totalled 2,739,257 tons, 1½% less than in 1953, and accounted for 49¾% of total U.S. Frasch production. This was augmented by recovered sulphur production from the 100,000 tons per annum plant at Worland, Wyoming, treating natural sour gas.

Exploration and development work on potential sulphur domes in the U.S.A. and in Mexico, sulphur deposits in Italy and Iraq, and on pyrites deposits are a testimony of the company's vigour in this field of activities. Its interest in the sulphur potential of Alberta sour gas and the development of sulphur ore and pyrites refining processes are indicative of the possible wider scope that the company's sulphur activities may take.

During 1954 the **Freeport Sulphur Company,** according to their annual report, achieved outstanding results in their sulphur and oil operations and expansion of their other mineral interests. Frasch sulphur production from five producing domes — Grande Ecaille, Hoskins Mound, Bay St. Elaine, Garden Island Bay and Nash — totalled about 2.1 million tons and this was augmented by a small output of sulphur from oil refinery gases at the company's plant at Westville, N.J. Sales during 1954, both as regards tonnage and revenue, were the highest on record and similarly net earnings and dividends payment attained a new high level.

The rise in annual production, amounting to one-half million tons during the past five years promises to continue, on account of substantial reserve capacity of existing domes, the addition early this year of Chacahoula dome, the proposed development of a major dome at Lake Pelto, and notwithstanding the final closure of the now exhausted Hoskins Mound. The company's bold development work, which in the latest project provides for production from an under-water dome, holds promise that Freeport may before long challenge the position of the world's premier sulphur producer.

Satisfactory operations during 1954 are reported by the **Duval Sulphur & Potash Company.** To ensure continued profitable yield of the company's sole producer — Orchard dome — which in 1954 produced only 169,400 tons sulphur, 26% less than in 1953, important technical improvements are believed to be in progress. Exploration for new deposits is being pursued.

In the **United Kingdom** consumption of sulphur in all forms* during the first quarter of 1955 amounted to 223,000 tons, 4% more than during the corresponding quarter of 1954, the previous highest. Consumption of elemental sulphur and in particular of "acid" sulphur continued to increase, acid so produced accounting for 37½% of total output. Sulphuric acid production of 536,500 tons (100% H_2SO_4) and consumption of 549,800 tons were the highest on record, underlining the high level of industrial activity. As the result of satisfactory operations at I.C.I.'s new anhydrite acid plant at Billingham, acid so produced increased by nearly one-half, whereas acid produced from spent oxide and pyrites acid, being least economical to produce, receded from the levels reached one year ago. Additional anhydrite acid supplies are shortly to reach the market from United Sulphuric Acid Corporation's new plant at Widnes and it is expected that this may primarily affect pyrites usage whilst highly competitive brimstone supplies continue to be available to the country's acid industry.

The lack of authentic detailed information permits only a general review of the **Sulphur and Sulphuric Acid Industries of the U.S.S.R.** This discloses that with annual production and

—*Excluding consumption of sulphur in anhydrite, for direct manufacture of ammonium sulphate, expected to total about 211,000 tons in 1955.

consumption at a rate of about 1.5 million tons sulphur the U.S.S.R. occupies second place in the world, although its consumption of sulphur is only 16lb. per capita compared with 73lb. in the U.S.A. and 47lb. in the U.K. Output is primarily in the form of sulphur in pyrites, non-ferrous smelter gases and also anhydrite, while elemental sulphur production, only about 100,000 tons per annum, results in part from natural deposits being augmented by sulphur produced by the Orkla process, and lately also from mirabilite. Of the current sulphuric acid output of about 3½ million tons per annum, 60% is taken up by the fertiliser industry. Lack of major sources of native sulphur and declining known pyrites reserves explain, under the prevailing policy aimed at the highest degree of self-sufficiency, the need to obtain sulphur from every possible source, irrespective of cost and labour, in order that the rapidly-growing demand may be met.

Production of elemental sulphur in **Japan** in 1954 totalled 185,700 tons, 2% less than 1953 and was contributed by only 28 producers, eight fewer than 1953. Consumption rose 4½% to 180,100, the increase being attributable primarily to the high level of viscose rayon production, one of Japan's principal export industries. The completion of a new refining plant by Matsuo in July, 1955, and the growing awareness for the need of such modernisation by other producers with a view to reducing costs, is hoped to make Japanese sulphur again competitive in world markets and to increase the present token level of exports.

The description of **Desulphurisation of Coke Oven Gas by the Collin Process,** as carried out at the plant of Messrs. Stewarts and Lloyds at Corby, Northamptonshire, underlines the importance of this development, as apart from providing the steel-maker with sulphur-free fuel and reclaiming sulphur previously wasted, it permits economic production of sulphuric acid. The wider application of this or one of the many other processes of desulphurisation and wet contact acid manufacture developed in recent years could make an important contribution to abate the pressing problem of air pollution.

The recently patented **Elliott-Ludlow Process** for sulphur ore refining based on the use of a saline solution ($CaCl_2$) to separate sulphur from its gangue holds promise of yet another means of economically treating mined native sulphur ore. Several plant manufacturers are examining it on behalf of the promoters, Associated Engineers, Limited, of Calcutta.

A paper on the results of the investigation by K. W. Downes and R. W. Bruce into **The Recovery of Elemental Sulphur from Pyrite and Pyrrhotite** was presented recently to the Canadian Institute of Mining and Metallurgy. The implications of this process, particularly to Canada's sulphur industry, are far reaching and the economics of its commercial development and application are now being investigated.

The immediate **supply position** of low-cost brimstone further improved. Output of Mexican Frasch sulphur is now at a rate of about 1,800 tons per day, and a slight further increase is expected. Several U.S. producers are reported to be operating below capacity, and the cessation of output at Hoskins Mound, has been more than made up by the start of operations at Chacahoula and the foreseen development of Lake Pelto. Chilean output is reported to be boosted by compensation-aided export sales, while in Italy the large stockpile still awaits disposal.

The demand for **pyrites** in Western Europe shows a slight improvement while that in the U.K. has receded. The increase in the cost of sulphur so consumed due to higher sea freights, is partly compensated by improved returns on residues now being obtained by Continental roasters.

The **world price,** in terms of the price of U.S. sulphur, has remained unchanged, but due to the growing supplies of Mexican sulphur offered in world markets at prices up to $3.50 below the equivalent U.S. price, there is marked downward pressure on prices. The disposal of substantial tonnages of Chilean sulphur to Western European consumers at below world prices and the subsidy now authorised, though still insufficient to facilitate the disposal of the Italian stockpile, add to the weakness of the market. The exploitation of this weakness to bring about a major drop in the world price is, however, not expected nor would it be in the interest of the world sulphur industry as this might eliminate useful marginal sources of supply and discourage potential development.

THE SULPHUR INDUSTRIES OF THE BRITISH COMMONWEALTH OF NATIONS

GENERAL

ONE of the main pillars of the economic strength of the British Commonwealth of Nations is its wealth of metallic and non-metallic mineral resources. Yet throughout the many Commonwealth countries, which together cover more than one-quarter of the earth's surface, there are practically no deposits of native sulphur, and of the few none are at present commercially exploitable. Available sulphur resources, which indeed represent a sizeable proportion of world reserves, are in other forms, notably metal sulphides, including pyrites, anhydrite, and sulphur recoverable from natural "sour" and industrial gases. Against this background the world sulphur crisis of 1951 can be said to have had a favourable effect, since it stimulated the production and use of sulphurous raw materials other than brimstone.

In most instances, however, such new acid-making facilities only came into operation after the essential need to reduce the use of brimstone had passed, and, in view of the favourable supply situation, the use of imported brimstone, favoured for economic reasons, is again re-asserting itself. This tendency has of course virtually no impact on integrated developments such as the acid industry based on by-product pyrites for the treatment of uranium ore in South Africa, or the new by-product acid plants based on lead and zinc smelter gases in Australia. The disparity in the cost of acid manufacture is particularly prominent in Australia, where the Government last year approved the payment of a bounty to users of indigenous raw materials. Nevertheless, the ease of brimstone supplies and the advantage in its use militate against the desired effect of this measure.

As shown in the table below, between 1948 and 1954, production of sulphur in various forms nearly doubled, the dependence of Commonwealth countries on imports from outside sources dropped from 65% of consumption to 55%, and its contribution to the sulphur requirement of other countries more than doubled. Simultaneously consumption increased by 47%, compared with an increase in free world consumption of only 32% during the same period.

	1948	*1954*
	000 tons sulphur	
Production	885	1740
Imports	1055	1320
Exports	250	510
Consumption	1640	2400

Resources

The following table indicates the type and approximate extent of proved and probable sulphur resources.

	Pyrite and Pyrrhotite	*Anhydrite Gypsum*	*Natural and† Industrial Gases*
	million tons sulphur		*000 tons S. p.a.*
Australia ...	12.1	*	10
Canada ...	58.3	*	260
Central African Federation ...	10.0	—	17
Cyprus ...	7.3	—	—
India	.3	75	—
New Zealand ...	—	—	—
Pakistan ...	*	37	3
Union of South Africa ...	*	—	10
United Kingdom	—	60	260
Other	1.0	—	5
	89.0	172	565

*—Not determined.
†—Recovery facilities installed or in sight.

No details are shown for sulphur reserves in non-ferrous metal sulphides, and the sulphur potential of available by-product acid or liquid SO_2 facilities employing smelter gases is included with those based on other sulphurous gases.

Anhydrite gypsum reserves have only been included where facilities exist for the use of the sulphur content of this material. In Canada and Australia, reserves, though not fully determined, are substantial, and are believed to exceed 50 million tons sulphur.

The recovery of sulphur from natural gas applies only to Pakistan and Canada. In the case of the latter, the cleaning of large-scale gas supplies for the trans-Canada pipe line is

expected to lead to the recovery of an additional quarter million tons sulphur by 1958.

Recovery facilities for sulphur in oil refinery and coal gases tend to be limited by the essential need for sulphur elimination and by the availability of a suitable outlet for the recovered H_2S or refined sulphur. The use of this source of sulphur is likely to assume greater importance in the near future.

Production and Consumption

In preceding issues of the *Quarterly Bulletin* the principal Commonwealth countries were reviewed in detail. This section of the article is intended only to report the latest developments.

AUSTRALIA

In 1954 consumption of sulphur in all forms is estimated to have totalled 285,000 tons, an increase of 5½% during the year. About 59% of total usage was represented by elemental sulphur, which was consumed as follows :—

	Tons
For sulphuric acid	159,247
„ agriculture	2,366
„ rubber compounding ...	1,885
„ other purposes	5,171
Total ...	168,669

Usage of regular sulphur remained at about the same level as in 1953, but "acid" sulphur consumption increased by about 27%, mainly because it remained the most economic of the various raw materials used by the Australian sulphuric acid industry, and was, moreover, in easy supply. Consumption of sulphur in pyrites and zinc smelter gases also increased, but, it is estimated, only by about 3% and 4% respectively.

Sulphuric acid production and consumption amounted to about 780,000 tons (100% H_2SO_4), 14½% more than in 1953 and the highest on record. Production resulted from the use of the following raw materials :—

Acid from :	*Tons*	%
Brimstone	471,939	60½
Pyrites	191,220	24½
Zinc concentrates ...	102,660	13½
Spent oxide	12,151	1½
Total ...	777,970	

The proportion of acid consumed for purposes other than fertiliser manufacture continued to increase slightly from about 9½% to 11%, although fertilisers absorbed the bulk of the increased output, and it is estimated that superphosphate output totalled 1,860,000 tons. Acid consumption by individual industries was as follows :—

	Tons 100% H_2SO_4	%
Superphosphate ...	636,060	81.7
Ammonium sulphate	57,550	7.4
Metallurgy	27,217	3.5
Chemicals	22,570	2.9
Other purposes ...	34,530	4.5
	777,927	

During 1955 a further increase in acid output may be expected as the result of several new plants which started operations either late in 1954 or early this year. These include the following :—

Sulphide Corporation, Ltd.: At Cockle Creek, N.S.W., a 100 tons per day contact acid plant based on Mount Morgan pyrites concentrates is to start operating in May, 1955.

North Queensland Fertilisers & Chemicals, Ltd.: A contact acid plant using brimstone started operating in December, 1954, supplying the company's acid requirements for superphosphate manufacture.

Albany Superphosphate Company: At Albany, W.A., a 20,000 tons per annum chamber acid plant using brimstone started operations in November, 1954.

Electrolytic Zinc Company of Australasia: At Risdon, Tasmania, the company's second contact acid plant based on sulphur in zinc smelter gases, with a capacity of 60,000 tons a year acid, mostly intended for ammonium sulphate production, started operating earlier this year. Its output is reported to be restricted to acid exports to the mainland, as the synthetic ammonia plant is not operating, due to power shortage. Construction of a third plant of similar capacity has been authorised, but not yet started.

Sulphuric Acid, Limited: At Birkenhead the 100,000 tons per annum contact acid plant, based on the use of Nairne pyrrhotite concentrates, is due to start operating in midsummer of this year.

Broken Hill Associated Smelters: At the Port Pirie, South Australia, contact acid plant, the company are expected largely to discontinue using brimstone in July of this year, when on completion of alterations to their lead sintering plant they will be able to use sulphur in the smelter gases to produce annually 45,000 tons acid.

Commonwealth Fertilisers & Chemicals, Ltd.: At Yarraville a 30,000 tons per annum contact acid plant based on brimstone is about to come into full operation. It incorporates spent acid fortifying facilities, which treat sludge acid from the nearby Altona Oil Refinery of Standard Vacuum Refining Company, who take up about 15,000 tons per annum of the company's acid output.

Whilst the benefit of the sulphur bounty introduced last year and at present amounting to £A2 per ton of acid will to some extent alleviate the financial disadvantages to users of indigenous sulphurous raw materials, whose plants are already installed or on the point of coming into operation, it is unlikely to stimulate further development in this direction. It is expected that with ample world supplies of brimstone, imports, which during the year ending 30th June, 1954, totalled 191,812 tons, may further increase, though it must be borne in mind that the Federal Government has not relinquished its statutory powers of import control and allocation, which at present stands at 100% of requirements.

CANADA

Sulphur production in 1954 amounted to 521,902 short tons, the highest on record, 22% greater than that of the previous peak year, 1952. It will be recalled that 1953 output was restricted by prolonged labour strikes at the mines of the principal by-product pyrites producers in Quebec.

The bulk of the increased output is reported to be attributable to the operation of Consolidated Mining and Smelting Company's Kimberley contact acid plant, which uses sulphur in pyrrhotite recovered as a by-product from the Sullivan concentrator. Statistically, as detailed below, this output is included under production from smelter gases.

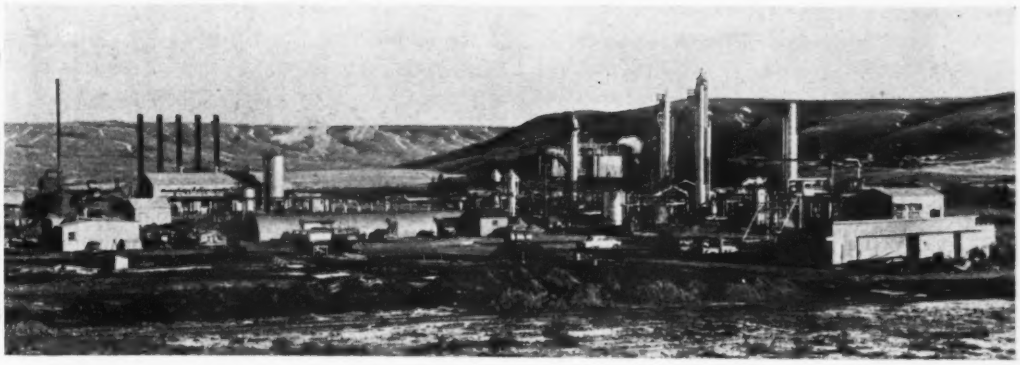
	1954	*1953*
	short tons sulphur	
Recovered from smelter gases ...	225,000	172,200
By-product pyrites (shipped) ...	278,037	186,650
Recovered from natural gas (shipped)	18,865	16,072
	521,902	374,922

Apparent consumption* amounted to 643,421 short tons, or about 40,000 short tons (6½%) more than in 1953, taking into account brimstone imports wholly from U.S.A. of 310,127 short tons (359,105 in 1953), and exports of sulphur in pyrites of 188,608 short tons (129,608 in 1953), of which, as in the past, about 74% were directed to the U.S.A., and the balance to the U.K. and the Continent. There has been no addition to the seven paper and pulp mills using pyrites for all or part of their SO_2 requirements, and there are no indications of further developments on these lines in the near future.

It is estimated that in 1955 elemental sulphur production will exceed 50,000 short tons, of which 35,000 short tons are expected to be recovered from sour natural gas, with the balance becoming available at the new plant of Noranda Mines, Limited, at Welland, which started in October, 1954. Using pyrites concentrates from the West McDonald mine, this plant is designed to yield about 18,000 tons elemental sulphur and the equivalent of 36,000 tons in the form of SO_2, which is being supplied to the contact acid converters of the adjacent plant of North American Cyanamid, Limited. The additional output of sulphur recovered from natural gas will originate from the plant of the Shell Company of Canada at Jumping Pound, which started operating at its new level of 80 short tons per day in January, 1955.

Sulphuric acid output totalled 922,674 short tons (100% H_2SO_4), 11½% more than in 1953, the previous peak year. Negligible imports and small-scale exports resulted in apparent acid consumption of 900,853 short tons. Fertilisers accounted for about 63% of consumption, chemicals for 15%, and other industries for 22%. The most important new development is the construction of a new 100 tons per day contact acid plant by Inland

*—In past years this calculated figure has exceeded reported actual consumption by up to 80,000 tons.



New sulphur recovery plant of Shell Oil Company of Canada at Jumping Pound.

Chemicals (Canada) Limited, at Fort Saskatchewan, Alberta, which, using sulphur recovered from natural gas, will supply acid to the adjacent synthetic ammonia plant of the Sherrit-Gordon refinery for ammonium sulphate manufacture.

The temporary inability of Trans-Canada Pipe Lines, Limited, to make adequate financial provision for their $300 million natural gas transportation project has postponed the start of construction by about one year. In consequence the large-scale arising of sulphur recovered from Alberta sour gas intended for supply to the pipeline may now only be expected from about 1958 onwards.

In view of the ready availability at low cost of fuel, power and a wide range of essential raw materials, Alberta promises to become a major centre of heavy chemical industry. A proportion of the expected sulphur output would be consumed locally, but, in view of the scope of this source of sulphur supply, its impact is likely to affect a much wider range of markets. For the present ample Frasch supplies are reaching East Canadian users at $35-45 per long ton, whereas in Western Canada Frasch sulphur from the U.S.A. and possibly also from Mexico may have to compete with output in excess of contracted quantities of recovered sulphur.

NEW ZEALAND

Consumption of sulphur, all of which is in the form of imported brimstone, totalled 96,700 tons in 1954, the highest level yet attained, and 27% greater than in 1953. "Regular" sulphur usage remained unchanged at about 3,000 tons, whereas consumption of acid sulphur rose from 73,000 tons to 93,700 tons.

Sulphuric acid production and consumption totalled 279,000 tons (100% H_2SO_4), of which all but 4,000 tons were used for superphosphate manufacture.

The completion of the new acid/fertiliser plant at Napier in mid-1954 increased the number of plants in New Zealand to eight, all of which are situated in the outskirts of a major town. The new requirements of the Napier works accounted for part of the increased sulphur usage, the balance being absorbed by greater use of existing capacities. In view of the overwhelming demand for superphosphate in the area, the Napier plant, which is expected to produce 100,000 tons (80% of its rated capacity) in its first year of operation, is to be enlarged, and new plant is on order to raise its capacity to 180,000 tons by the end of next year. New projects provide almost exclusively for plants of about 100,000 tons per annum superphosphate based on the use of brimstone at the rate of 12,000 tons per annum each. The following are under consideration: *The Bay of Plenty Fertiliser Works, Limited,* of Tauranga, a co-operative enterprise, at Mount Maunganui. *The Kiwi Fertiliser Company, Limited,* a joint enterprise by the long-established Challenge Phosphate and New Zealand Farmers' Companies, at Morrinsville. In Southland further developments await a Government recommendation as to the relative merits of fused calcium magnesium phosphate and superphosphate production. More distant schemes envisaging

new plants at Whangarai (North Auckland), Timaru, and Wellington, have been mooted.

It is expected that in 1955 sulphur requirements will rise further to 118,000, and, continuing to increase progressively in line with the anticipated development of fertiliser plants, should reach 150,000 tons per annum by 1960. The alternative use of Australian pyrites, which at one time held up developments, is now no longer being considered.

There is a possibility of small-scale sulphur recovery, less than 1,000 tons per annum, from geothermal steam, in connection with the heavy water and power project at Wairakei, where, under the present programme, a 40,000 kilowatt power plant is to be completed by 1958. Any extension of the scheme would probably add to the sulphur recovery potential, but, compared with requirements, this would still be negligible. During 1954 New Zealand imported 133,100 tons of brimstone from U.S.A. Imports from U.S.A. and probably from Mexico are likely to remain the country's main source of sulphur supply, although Japan can provide strong rivalry if she can reduce her present production costs.

CYPRUS

Production of sulphur, in the form of pyrites and copper concentrates, in 1954, is estimated to have totalled 410,000 about 11% more than in 1953, but about 4% less than the peak output of 1952.

Over 70% of total production was contributed by the Cyprus Mines Corporation in the form of about 681,000 tons cupreous pyrites. Differential flotation of the bulk of the ore output yielded 453,000 tons flotation pyrites, about 30,000 tons more than in 1953, 73,300 tons copper concentrates, and about 2,300 tons cement copper.

The Hellenic Mining Company continued to extend their lease and prospecting areas, and made important ore discoveries in the Mitsero Agrokipia area. Plans for an ore treatment plant in the new mining region have been completed. Total production from the company's three mining areas amounted to over 217,000 tons pyrites, 30% more than in 1953.

Cyprus Sulphur and Copper Company completed their new ore treatment plant, and, having rebuilt the aerial ropeway, started production in the Limni open-cast mine.

In the absence of domestic sulphur users, the entire output of Cypriot mines was available for export, which totalled 430,000 tons sulphur in pyrites and copper concentrates, 16% more than in 1953. Cyprus remains the largest exporter in the British Commonwealth, and, in view of the high quality of Cypriot pyrites, consumers' demand in the U.K. and Europe, the principal export markets, tends to exceed available supplies.

INDIA

The country's rapidly-expanding fertiliser requirements have resulted in a further substantial increase in sulphur consumption. It is estimated that in 1954 this totalled 160,000 tons, an increase of about 10%, of which about 95,000 tons was in the form of gypsum for direct manufacture of ammonium sulphate, and the balance in the form of imported elemental sulphur. Consumption for non-acid uses remained unchanged at about 15,000 tons, but acid sulphur usage increased by one-quarter to 50,000 tons, largely as the result of greater consumption for superphosphate manufacture, which increased from 48,000 tons in 1953 to 105,000 tons in 1954.

Installed acid capacity in midsummer, 1954, totalled 204,800 tons (100% H_2SO_4). New installations include :—

Dharamsi Morarji Chemical Company : A 25 tons per day contact acid plant is intended to supply the acid requirement of the Burmah-Shell oil refinery.

National Rayon Corporation : Plant extensions to double the present acid capacity of 3,200 tons per annum are foreseen.

D.C.M. Chemical Works : At Delhi, a 25/30 tons per day contact acid plant is being erected.

Hyderabad Chemicals & Fertilisers, Limited : A 20 tons per day contact plant is to supply the company's increased acid needs for superphosphate production.

East India Distillers and Super Factories : A 20 tons per day contact acid plant is to be built in Andhra, also for superphosphate manufacture.

The Rajah of Venkatagiri : The projected gypsum acid plant under construction by Zahn & Co., Hameln, Germany, will now have a daily capacity of 50 tons, its output to be used for superphosphate production.

The National Industrial Development Corporation, which controls all new developments, is intensifying the promotion of projects aimed at reducing India's dependence on foreign sulphur. So far, with the exception of the possibility of using smelter gases from the Zawar zinc and the Ghatsilla copper smelters, these do not show promise.

Elemental sulphur imports in 1954 totalled 72,189 tons (valued at £17 10s. per ton), to rise to 86,000 tons in 1955.

PAKISTAN

The completion in recent weeks of the 348-mile gas pipe line from the Sui gasfields to Karachi promises the early start of sulphur recovery operations, which are expected to provide Pakistan industry with about 2,500-2,700 tons per annum elemental sulphur, which, at present rates of consumption, is expected to meet domestic needs.

The fertiliser project at Daud Khel, where ammonium sulphate is to be produced by direct use of gypsum, is progressing, and the plant is now expected to start operations by the end of 1956. Gypsum consumption is planned at a rate equivalent to 37,000 tons sulphur.

UNION OF SOUTH AFRICA

During 1954, production of by-product pyrites in conjunction with uranium oxide production from gold-ore slimes expanded rapidly, and was 2½ times greater than in 1953. The total sulphur consumption in the Union during 1954 is estimated at 205,000 tons. Of this, domestic production provided about 108,000 tons sulphur in pyrites, while the entire brimstone requirements were imported, as well as about 30,000 tons pyrites from Southern Rhodesia, as during 1953.

Acid production in the non-uranium sector of the industry is estimated to have totalled 260,000 tons (100% H_2SO_4), of which about three-quarters was produced from imported brimstone and the balance, with the exception of about 1,500 tons spent oxide acid, from pyrite and pyrrhotite. In addition to about 73,000 tons acid sulphur, some 11,000 tons "regular" sulphur was consumed by non-acid industries.

The £30 million plant of South African Coal, Oil, and Gas Corporation, Limited, producing oil from coal, started operations during 1954. It provides for the production of up to 35,000 tons by-product ammonium sulphate, but is not known to what extent this section of the plant was working. Some 10,000 tons sulphur in the form of H_2S are expected to arise in the course of coal hydrogenation, but for the time being recovery is not foreseen, and the H_2S gas will be exhausted to the atmosphere diluted about 100 times with CO_2 and air.

OTHER COUNTRIES

In Trinidad, at the oil refinery of Trinidad Leaseholds, Limited, output of sulphur recovered from oil refinery gases increased by over one-third to 4,300 tons in 1954. About one-half of the output is captive, to meet the refinery's sulphuric acid needs ; the balance is exported to the U.K., where, because of its purity, this material is highly valued. A further increase in output to about 5,000 tons is foreseen for the current year.

CONCLUSION

Notwithstanding the substantial expansion of production and use of indigenous sulphurous raw materials, every major sulphur-using country in the British Commonwealth is vitally dependent on imports of elemental sulphur. These represented 59% of total consumption in 1948, and 48% in 1954, having at the same time increased by about 175,000 tons. The freer availability of low cost elemental sulphur from the U.S.A., and now also from Mexico, has caused individual consumers and controlling agencies to give prior consideration to the economics of sulphuric acid production when earlier greater emphasis was attached to the use of substitute sulphurous raw materials.

In consequence, beyond the projects for the production or consumption of sulphur in forms other than brimstone initiated in earlier years, at present only limited expansion is envisaged in this field. This does not, of course, apply to projects providing for the recovery from natural, petroleum, or industrial gases, of sulphur in elemental form or as sulphuric acid. In fact, this sector of the industry is expected to increase in importance since its economics are generally favourable and because of its impact on the problem of air pollution, which, especially in the U.K., is receiving serious attention.

With the expansion of sulphur consumption in all forms, which in the British Commonwealth is expected to continue at an annual rate of about 5%, its individual markets at present absorbing about two-thirds of world exports of elemental sulphur will tend to assume even greater importance in the world sulphur trade.

Prices and Trends

ALTHOUGH during the past three months there has been no change in the world price, as represented by the price of American sulphur, the downward pressure resulting from the abundance of supplies, in particular of Mexican Frasch sulphur, has continued. The renewed rise of sea freights from the end of March onwards increased the delivered costs of brimstone to U.K. and Continental users by about 3%, with increases of up to 8% to other destinations.

Mexican producers were very active in all markets, in the face of strong sales promotion by the established U.S. producers. As yet the offers of Mexican sulphur continue to be very flexible and aim to attract business in specific markets by competitive quotations which are reported up to $3.50 less than the corresponding export price of U.S. sulphur. Charters of Mexican sulphur from Coatzacoalcos remain at a slight disadvantage compared with U.S. Gulf ports, but port and loading facilities have proved to be satisfactory, and it is expected that before long, at least in the case of vessels arriving in ballast, the differential will cease.

In an effort to move some of the Italian stockpile supplies, the Ente Zolfi Italiani, aided by a Government subsidy, now totalling Lire 11,000 (£6 5s. 6d.) per metric ton, have substantially reduced their official quotations. Nevertheless, as shown below, these still exceed world price levels and some of the export sales reported to have been effected in recent weeks were made at more competitive prices* :—

Gialla Superiore	L. 28000 per metric ton	(£16 10s.)
Gialla Inferiore	L. 27100 „ „ „	(£15 10s.)
Buena Sicilia ...	L. 26200 „ „ „	(£15 0s.)

The effective price of Chilean sulphur, at which a substantial volume of sales was transacted during the past months, remained at about U.S. $23-24 per metric ton f.o.b. To meet the official Chilian export price ($32) and producers' costs which are said to range up to the free-rate equivalent of U.S. $50, the above sales price is supplemented from the proceeds of compensating commodity imports, notably machinery and goods vehicles, all transactions being promoted by the Chilean National Institute of Commerce (I.N.A.C.O.).

The following table shows a comparison of prices of sulphur of different origin. F.o.b. prices and freights are based on recent quotations :—

	f.o.b. Country of origin	*Freight* to U.K.*	*c.i.f. U.K. per ton*
U.S.A.	U.S. $29.50 - $33	80/-	£14¾ - £15¾
Mexico	U.S. $26.50 - $29.50	80/- - 85/-	£13½ - £14¼
Italy/Sicily ...	L. 28,000	58/-	£19⅛
Chile .. .	$23-24	100/-	£13⅛ - £13¾
Japan	U.S. $34†	98/-	£17⅛
Ecuador	U.S. $42	95/-	£19¼
Canada	$20 ex works	100/-	£19

*—Based on bulk cargoes of 5,000 to 6,000 tons on the usual sulphur terms of chartering.
†—Calculated on basis of sales to Australia.

Prices of European pyrites remained unchanged at £4 15s. to £5 5s. per metric ton f.o.b. Canadian pyrites are reported to be readily available at up to $5 per short ton f.o.r. mine, with export values in 1954 ranging from about $3.10 on ore exported to U.S.A. to $6.70 in the case of U.K. shipments. The upturn in sea freights has increased the cost of sulphur in pyrites to U.K. and Continental consumers by about 10%, although, in the case of the latter, this has been partly offset by improved returns on pyrites residues.

Supply

Production in the U.S.A. during the past three months is reported to have shown little change from the comparatively restricted level of the first quarter of the year. As the result of the high level of activity in the rayon, pulp and sulphuric acid industries, the last-named stimulated specially by the needs of the steel, detergent and petroleum industries, domestic demand for sulphur remained strong, and was

*—6,000 tons reported sold to France and Czechoslovakia at L.23,000 and L.24,000 per metric ton respectively.

supported by buoyant exports. Producers are comfortably meeting all demands made upon them, and in part the lower rate of Frasch sulphur output is believed to be occasioned by some producers' desire to limit above-ground stocks. At the end of May the oldest producing dome — Hoskins Mound — finally ceased operations due to exhaustion. In thirty-two years' continuous activity, it yielded over 10.9 million tons sulphur compared with its original estimate of reserves of 11 million tons. In this connection it may be of interest to note that the reserves of Boling, the world's largest dome, were assessed in a scrupulously accurate survey described by Williams Haynes, the author of "The Stone that Burns," at 46 million tons sulphur ; this, the only published estimate, was made in 1929. By the end of 1954, in twenty-five years' operation, Boling had yielded 44.5 million tons.

Production of Frasch sulphur in Mexico is reported to have been raised to over 1,800 tons per day. Pan American Sulphur Company at Jaltipan are said to be producing at 1,500 tons per day, and Mexican Gulf Sulphur Company at San Cristobal are reported to have overcome their recent technical difficulties and, having regained their earlier output rate of 350 tons per day, are now aiming to increase it to 500 tons. Both companies have executed some export shipments, and are reported to have substantial orders on their books. At present, stocks at their mines and at the port are growing rapidly, and according to current indications may total over one-half million tons by the end of this year. The third company, Gulf Sulphur Corporation, are now expected to start operations at their Las Salinas dome by the end of October, three months later than originally planned.

Notwithstanding the limited output of Italian sulphur, further additions to the stockpile are reported. So far no major sales of stockpile sulphur have taken place, although some export orders are said to have been secured by Ente Zolfi Italiani, following the price reduction by subsidy.

As the result of a large volume of compensatory commodity imports, notably from France and Western Germany, substantial export orders have been secured by the Chilean National Institute of Commerce and the output of Chilean sulphur appears to be fully booked for several months ahead. According to reports from Santiago, it is expected that during 1955 production may reach installed refining capacity of over 100,000 tons as, in addition to increased domestic needs of 25,000 to 30,000 tons, exports of up to 80,000 tons may be effected.

In Ecuador, the Ecuadorian Mining Corporation, S.A., operating the Tixan deposit is increasing its output, which is expected to reach 15,000 tons this year. The company has engaged in several long-term contracts for domestic and export delivery.

The world supply position in the immediate future is expected to remain easy with more than adequate supplies and reserve production capacity ready to satisfy existing and new demand. Whilst offers of Mexican sulphur at less than world prices are a welcome development to all consumers it is not thought that a major overall price reduction would be in the interests of the industry, since it could well elmininate useful marginal supplies and discourage potential developments.

UNITED STATES SULPHUR

Native Sulphur

DURING the first quarter of 1955 production of Frasch sulphur amounted to only 1,281,350 tons, a decrease of over 117,000 tons (8½%) compared with the preceding quarter and also 97,000 tons (7%) less than during the corresponding period of 1954. This reduction occurred notwithstanding the increase in available capacity mainly as the result of production started at Freeport Sulphur Company's Chacahoula dome.

Apparent sales, stimulated by strong domestic demand, amounted to 1,418,473 tons, the second-highest total on record, representing an increase of 18,000 tons (1¼%) over the preceding quarter. The increase of more than ¼-million tons compared with the corresponding period of 1954 reflects the higher level of activity in the sulphur using industries, which was particularly noticeable in March when apparent sales rose to 544,212 tons, an annual rate of over 6½ million tons.

The high level of sulphuric acid production — over 3.9 million short tons in the first quarter 1955 — was occasioned by a strong demand particularly in the steel, fertiliser, petroleum and detergent industries.

A rail strike in the South has seriously hampered output at one of the largest U.S. acid plants, and substitute supplies brought in from a distance mainly for phosphate acidulation have temporarily altered the supply position.

Among non-acid users the increased requirements of the rayon industry were outstanding, while the needs of the pulp and rubber industries continued at a high level. Exports of Frasch sulphur in the first quarter totalled 339,276 tons. In line with seasonal trends — notably the low level of winter exports to Canada — shipments were 26% lower than in the preceding quarter, but 11½% greater than during the corresponding period of 1954.

In view of the comparatively low level of output, Frasch sulphur stocks at mines and in transit receded over 137,000 tons during the quarter and at end March totalled 3,090,897 tons.

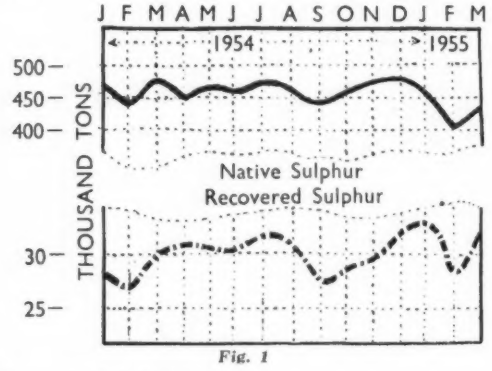


Fig. 1

Recovered Sulphur

Production of sulphur recovered from natural and oil refinery gases during the first quarter of 1955 totalled 93,600 tons, the highest on record. Output was 3,600 (4%) greater than in the preceding quarter and 8,600 (10%) greater than during the corresponding period of 1954. January production of 33,200 tons was the highest monthly total yet achieved by this section of the industry, whose capacity was raised by 130 tons a day in February when Jefferson Lake Sulphur Company's new recovery plant at Manderson started operations.

Apparent sales of recovered sulphur amounted to 78,657 tons, an exceptionally high total for a period that usually shows seasonally low off-take figures. Approximately the same as sales during the preceding quarter, they were nearly 18,000 tons (29½%) greater than those of the corresponding period of 1954. In view of the record output, stocks increased further by about 15,000 tons and at the end of the quarter totalled 124,009 tons.

Summary—1st Quarter, 1955

(a) Production of native and recovered sulphur of 1,374,950 tons was 7½% lower than in the preceding quarter and 6% lower than during the corresponding period of 1954, notwithstanding the substantial additions to productive capacity.

(b) Apparent sales of native and recovered sulphur totalled 1,497,130 tons, the third highest quarterly tonnage on record. Whereas in the second quarter of 1953 demand was boosted by an impending rise of prices and that of the second quarter 1954 by heavy export orders, the current position is primarily the result of the high level of activity in the domestic sulphur using industries.

(c) Stocks of native and recovered sulphur at the end of March totalled 3,214,906 tons, a reduction of over 155,000 tons compared with the same period in 1954, thus reversing the trend of the past year. In part this has been due to the lower rate of Frasch sulphur production, believed to be the result of a deliberate act of policy by the producers, aimed at limiting the volume of stocks, although this appears to conflict with Government wishes. The effect of this has been accentuated by exceptionally high demand during March.

(d) Increasing consumption of natural gas by domestic and industrial users and the growing proportion of sour crude oil consumed by oil refineries point to a steady increase in sulphur recovery from these sources, although the future rate of expansion is not expected to be as rapid as during recent years.

Texas Gulf Sulphur Company

ACCORDING to the Annual Report for 1954, presented by Mr. Fred. M. Nelson, the company's President, gross and net financial results were the highest in the company's history. Demand on the company for sulphur, the report states, continued at a rate approximately equal to production, which originated from Newgulf (Boling), Moss Bluff and Spindletop domes in Texas and the recovery plant from sour natural gas at Worland, Wyoming. At Spindletop the company continued to purchase oil interests in the cap rock area of the dome. Exploration, the report states, was carried on during the year in various areas, including Mexico, and the company acquired and extended rights and options on prospective properties.

equivalent of $2.45 in 1953. Dividend payments totalled $1.83 per share in 1954, compared with the equivalent of $1.67 in 1953.

General Information

Although Texas Gulf Sulphur are still the largest single sulphur producer in the world this position may before long be seriously challenged by the Freeport Sulphur Company whose rising trend of production significantly contrasts with the continued decline of output by Texas Gulf Sulphur which, it is believed, is only in part the result of deliberate policy.

The following graph indicates the development of the company's Frasch sulphur output, which in 1954 totalled 2,739,257 tons, 1½% less than in 1953 and accounted for 49¾% of total U.S. Frasch production.

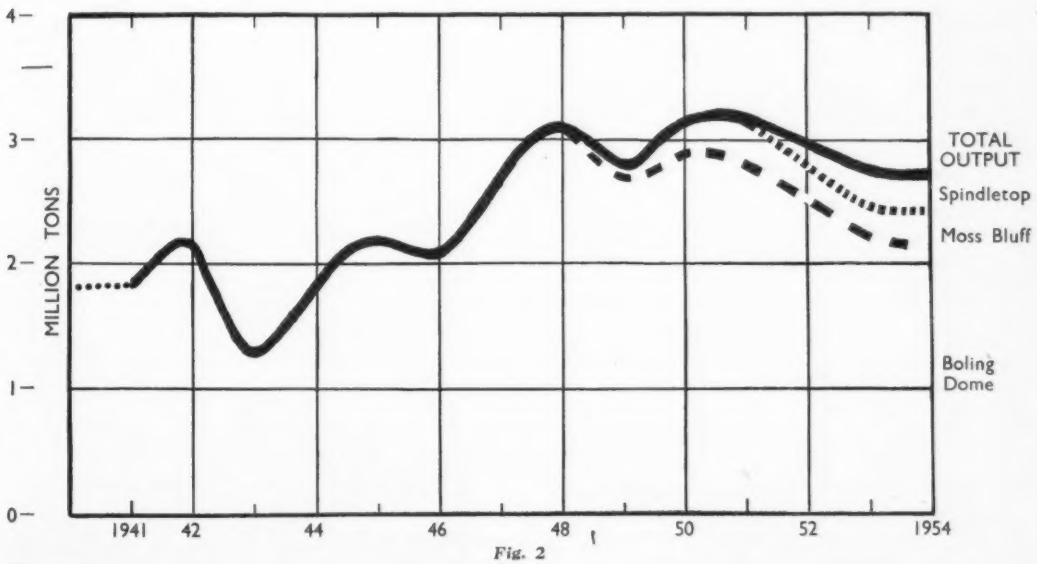


Fig. 2

Finance

Costs and expenses of $39,430,120 reduced the company's gross revenue from sulphur sales to $45,120,714. This net income from sulphur operations was augmented by miscellaneous other income and after tax payment of $15,700,000 the company had a net earned income of $30,544,951 corresponding — following the three for one share split on 20.12.54 — to $3.05 per share, compared with the

The company's exploratory work on the Isthmus of Tehuantepec in Mexico has not so far met with success and it is reported that a new concession adjacent to the property of Mexican Gulf Sulphur Company has been acquired. Development work on Lake Bullicamp and Fannett domes continues but there is no indication as yet when and to what extent these will operate.

In Italy Texas Gulf Sulphur Company subsidiary, Cosmin S.A., is very active with geological survey and prospecting work. In mid-May the company were granted a major concession in the Agrigento area resulting in a one-day strike by the Communist labour union (CGIL) as a protest against "a foreign company being given the largest sulphur deposit in Sicily which is likely to be exploitable by the Frasch process."

In Iraq (see *Quarterly Bulletin* No. 8, p.42) negotiations to secure a major sulphur concession failed, although it is now rumoured that a new approach has been made. In November, 1954, it was reported that Northern Pyrites Corporation, a Texas Gulf Sulphur subsidiary, had acquired an option on an important pyrites property on Latouche Island, Prince William Sound, Alaska. Interest in the sulphur potential of Alberta sour gas, in the development of elemental sulphur production from pyrites and in a new sulphur ore refining process reported to have been developed by Texas Gulf Sulphur are indicative of the possible wider scope that the company's sulphur activities may take.

Freeport Sulphur Company

THE Annual Report and Balance Sheet for 1954 disclose continued growth of activities, notably in sulphur and oil, and expanding interest in other minerals.

Sulphur

For the first time in the company's history, sulphur production exceeded two million tons, with Frasch output being augmented by a small amount of sulphur recovered from petroleum refinery gases.

The principal contribution to the increased output in 1954 was made by Garden Island Bay dome, which has an output capacity of one half-million tons and which started to yield in November, 1953. Grande Ecaille dome remains the company's largest producing unit, and the balance of production was provided by Bay St. Elaine, Nash and Hoskins Mound domes. The last-named still contributed over 170,000 tons but its production costs, the report states, have risen steadily for the past nine years and only the increase in the sales price of sulphur have permitted its continued exploitation. Now its reserves are stated to be quite close to exhaustion. Chacahoula, the company's newest dome, did not affect the year's results, having only started operation in March, 1955.

During 1954 sales, both as regards tonnage and revenue, rose to the highest level on record.

Oil, Gas and Other Mineral Interest

For the first time in six years, since the company started on its oil and gas exploration programme, positive results were achieved in 1954. Net production, notably from wells at the Lake Washington Field and Bayou Choctau, both in Louisiana, totalled 1,125,000 barrels, the daily rate having risen to 3,600 barrels.

Garden Island Bay Dome. Power plant in foreground.

The company's other interests concern nickel and potash. The former are represented by the operation of an important deposit in

Cuba, worked by a wholly owned subsidiary, the Nicaro Nickel Company. A pilot refining plant is due to be completed this autumn and, given a satisfactory performance, the company may enter into an agreement with the U.S. government to erect a full-scale plant.

The company's mineral rights in the potash deposits in Carlsbad, New Mexico, are to be exploited in conjunction with Pittsburgh Consolidated Coal Company with whom they have formed a joint subsidiary—the National Potash Company—which expects to start production in 1957 at an annual rate of one quarter-million tons K_2O.

Finance

The operating profit totalled $13,272,438, compared with $10,538,656 in 1953, the highest on record, representing $4.20 per share of common stock.

After provision for taxes, the company's net income amounted to $10,083,938, an increase of nearly $1\frac{1}{2}$ million ($18\frac{1}{2}\%$) compared with the previous year. Dividends payments in 1954 totalled $2.50 per share compared with $2 in 1953.

Review and Progress

The outstanding results of the year's sulphur operations reflect the success of Freeport's bold four-dome investment programme. During the last five years total output has risen by one half-million tons and in this period the gap between Freeport's production and that of the world's leading producer (Texas Gulf Sulphur Company) has narrowed from 1.59 million tons to 0.67 million tons. The following graph shows the development of the individual domes' production during the period 1941-1954.

During a recent conversation in London with Mr. Charles A. Wight, Chairman of the Executive Committee, and Mr. Thomas R. Vaughan, Vice-President and Director of Sales, the company's activities and prospects were discussed. This year, with the company's potential further increased by Chacahoula dome, the aggregate output whilst aligned to the rising sales demand is well below available productive capacity. The company's smallest dome — Nash — which started operation in February, 1954, has met with some production

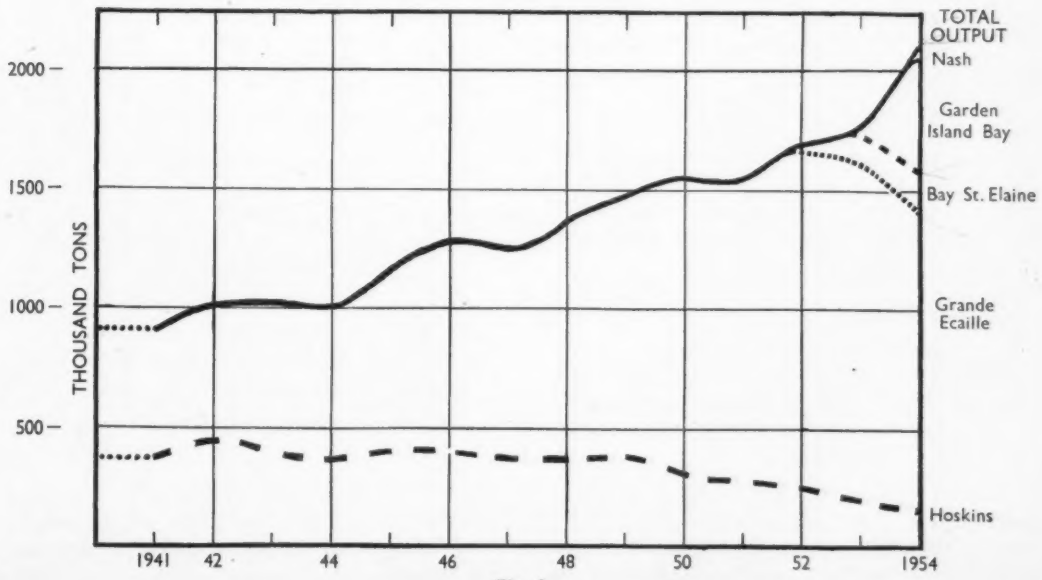


Fig. 3

difficulties resulting in an output of only 27,600 tons during that year. Although it is expected that it will soon reach its rated capacity of 70,000 tons a year, its reserves are small, and it is not expected to produce for more than another two or three years.

Bay St. Elaine has shown satisfactory results, but sulphur reserves here are also limited, and intensive extraction, at a rate of 500 tons a day, is expected to exhaust this deposit in under three years.

On May 27th, Hoskins Mound was finally closed down, due to exhaustion of the deposit.

This sulphur dome had been operating without interruption since 31st March, 1923 — longer than any other United States sulphur mine — and in this time produced about eleven million tons of sulphur.

Two days earlier, the company had announced plans for a major dome development at the newly-discovered Lake Pelto deposit, six miles from Bay St. Elaine and about sixty miles south-west of New Orleans. This decision was reached by the company's Board following detailed prospecting operations which had started early this year. The dome lies under six to eight feet of water—separated from the open Gulf by only a narrow spit of sand — and its exploitation will involve Freeport for the first time in under-water operations, with new and difficult engineering problems not previously met by their engineers in the tidal marsh lands where Garden Island Bay and Bay St. Elaine are situated. It is foreseen that the plant now at Bay St. Elaine will be transferred to the new dome which gives promise of becoming the company's third largest producer.

Duval Sulphur and Potash Company

ACCORDING to the Annual Report for 1954 presented by the President, Mr. Geo. F. Zoffman, operations of the company's sulphur and potash properties yielded a net income of $3,071,616 ($3,045,162 in 1953). Dividend payments amounted to $1.25 per share on the issued and outstanding capital stock, the same as in 1953. The company continued to seek new commercial deposits of sulphur, potash and other minerals. During the year various properties in Texas, Arizona and New Mexico were explored at a cost of $539,000, but without yielding satisfactory results.

Comment on Sulphur Operations

Output at the company's Orchard dome during 1954 totalled 169,400 tons, 26% less than in 1954. The following graph shows details of production since 1938, when output started at Orchard dome.

It is reported that important technical improvements are being made at Orchard dome, which the company hope should permit output to be maintained at an annual level of about 200,000 tons for at least five years. The exploration work at High Island dome appears to have been abandoned and the concession rights disposed.

In spite of the work on the Orchard dome aimed at ensuring its continued profitable output, the company undoubtedly have a serious need for a substantial new source of sulphur supply and to this end they are vigorously proceeding with the examination of potential properties.

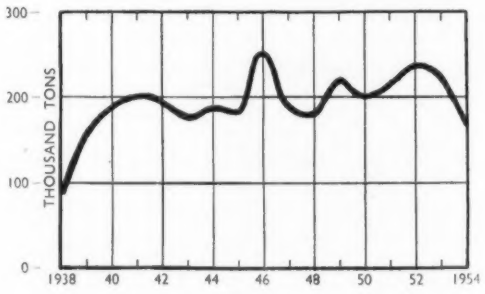


Fig. 4

UNITED KINGDOM SULPHUR

DURING the first quarter 1955 consumption of sulphur in all forms* amounted to about 223,000 tons, the highest quarterly total on record, or about 4½% greater than during the preceding quarter and 4% greater than during the corresponding period of 1954. Consumption of elemental sulphur, 8¼% greater than during the first quarter 1954 and 2¾% greater than in the preceding quarter, was the highest since the peak level of 1950.

"Acid sulphur," of which over 10% originated from domestic sources, rose to an annual rate of 290,000 tons, whereas "regular" sulphur consumption in the first quarter receded 6¼% from the peak level of the preceding quarter.

It is estimated that of the above total consumption 33¼% was met from indigenous sources (sulphur in spent oxide, anhydrite, zinc smelter gases and recovered from coal and oil refinery gases), 26¾% in the form of imported pyrites, and 40% in the form of imported brimstone. Actual imports amounted to 115,601 tons brimstone (valued at £14/17/- per ton) and 128,120 tons pyrites (valued at £6/19/6 per ton).

Monthly consumption figures of raw materials were as follows :—

	1st Qtr. 1955 Tons	*4th Qtr. 1954 Tons*	*Change† %*	*1st Qtr. 1954 Tons*	*Change† %*
Sulphur					
Acid	72,500	68,000	+ 6½	64,500	+12½
Regular	28,500	30,400	− 6¼	28,800	− 1
Total	101,000	98,400	+ 2¾	93,300	+ 8¾
Pyrites	124,600	123,000	+ 1¼	130,000	− 3½
Spent Oxide	69,700	69,800	—	76,800	− 9½
Anhydrite	66,100	45,600	+45	44,700	+48
Zinc concentrates ...	48,900	44,200	+10½	49,100	− ½

Consumption of the various raw materials were as follows :—

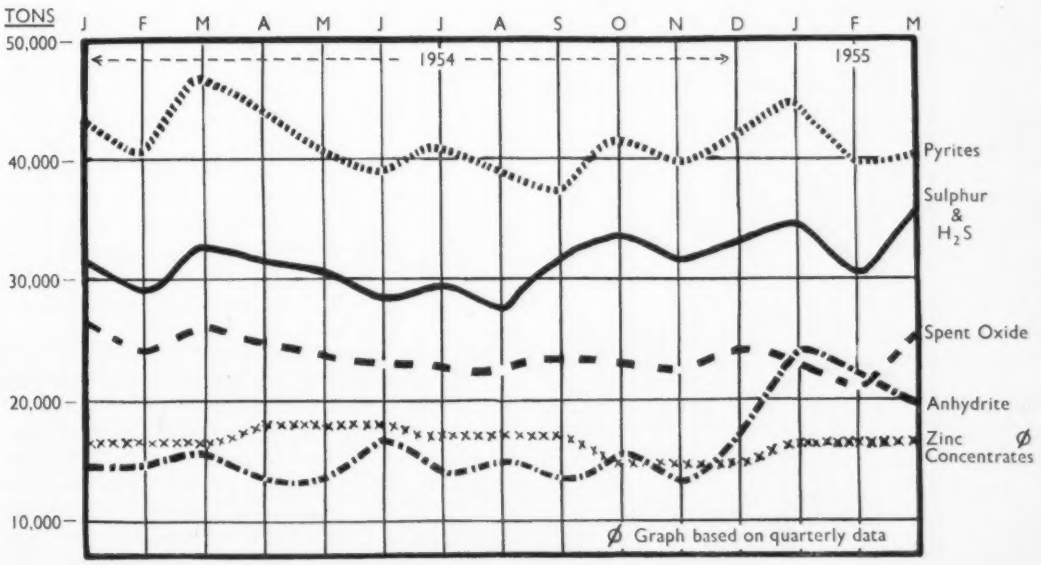


Fig. 5

*—Excluding consumption of sulphur in anhydrite for direct manufacture of ammonium sulphate, which is expected to total about 211,000 tons in 1955.

†—Percentage figures shown indicate change between earlier periods and the first quarter, 1955.

Sulphuric Acid†

Production during the first quarter amounted to 536,500 tons (100% H_2SO_4), the highest quarterly total on record. Output, representing an annual rate of 2.15 million tons, was 4½% greater than during the preceding quarter and 2% greater than during the corresponding period of 1954, the previous highest.

Acid production resulted from the use of sulphurous raw materials in the following proportions :—

	1st Qtr. 1955 %	4th Qtr. 1954 %	1st Qtr. 1954 %
Sulphur and H_2S ...	37¼	36¾	34¾
Sulphur in :			
Pyrites	30½	31¾	32¼
Spent Oxide ...	17¼	19	19¾
Anhydrite	7¼	5	5
Zinc Concentrates ...	7¾	8	8¼

During the first quarter of 1955 effective production capacity rose to an annual rate of 2.49 million tons acid of which 86.2% was employed. The increase is primarily attributable to the new anhydrite acid plant of Imperial Chemical Industries at Billingham which started operating at the end of December, 1954. Contact acid production of 371,800 tons accounted for 69½% of total output, compared with two-thirds during the corresponding period of 1954.

Employment of sulphur burning capacity rose to about 87%, while that of pyrites roasters and spent oxide burners was about 82% and 88% respectively.

Consumption of sulphuric acid amounted to 549,800 tons (100% H_2SO_4), the highest on record in any quarter, representing an increase of 5½% over consumption in the preceding quarter and of 3% over that of the first quarter 1954, hitherto the highest.

Acid usage by the main consumer groups was approximately as follows :—

	000 Tons	%
Fertilisers	211	(38.3)
Chemicals	70(est.)	(12.7)
Titanium and Lithopone ...	59	(10.8)
Rayon and Transparent paper ...	68	(12.4)
Iron and steel	31	(5.6)
Oil Refining	14	(2.5)
Dyes	21	(3.8)
Miscellaneous	76	(13.9)
Total	550	(13.9)

†—We are indebted to the National Sulphuric Acid Association for information placed at out disposal.

The principal changes in individual consuming industries compared with the corresponding period in 1954 were as follows :—

	Change Tons	%
Titanium Dioxide ...	+4,000 tons	(+ 8)
Rayon and Transparent paper	+3,400 „	(+ 5)
Soap, Glycerine and Detergents	+3,300 „	(+31)
Iron Pickling	+3,300 „	(+11)
Sulphate of Ammonia ...	−2,300	(− 3)
Bromine	−2,300	(−45)

Quantitively smaller, but nevertheless significant changes, occurred in acid use for Clays (+50%), Paper (+28%), Drugs and Fine Chemicals (+22%), Tar and Benzole (−20%).

Consumption of acid for superphosphate manufacture — the largest single use — remained practically unchanged (−¼%).

Raw Material Stocks

During the first quarter of 1955 stocks of brimstone increased by about 13,500 tons and at the end of March totalled 80,700 tons, representing about 10 weeks' consumption at current rates. At the same time in 1954 sulphur stocks amounted to 82,300 tons. Stocks of pyrites decreased about 8,500 tons to 180,200 tons, and stocks of spent oxide receded 5,800 tons to 136,200 tons, representing about 19 weeks and 25 weeks consumption respectively.

The most significant features of development in the sulphur industry during the first quarter are :—

(1) Peak levels of sulphur consumption and sulphuric acid production and consumption, the latter partly influenced by seasonal trends but, nevertheless, underlining the high level of industrial activity in the country.

(2) The increase by nearly one-half of anhydrite acid production as the result of operations at I.C.I.'s new Billingham plant.

(3) The increased use of elemental sulphur in acid manufacture, at the expense primarily of pyrites.

During the second quarter the anhydrite acid plant of United Sulphuric Acid Corporation is expected to start operations and its supplies are likely to influence the pattern of consumption probably from mid-summer onwards. This is likely to result in a further reduction of pyrites consumption and also affect, to a lesser extent, " acid-sulphur " usage.

Sulphur and Sulphuric Acid in the U.S.S.R.

THERE is a regrettable lack of authentic, detailed information on the sulphur producing and consuming industries of the U.S.S.R. This article attempts to present such information as is available.

The level of sulphur usage in various forms has increased substantially in recent years in line with the rapid growth of general industrial activity. Compared with the abundance of most industrial raw materials there is a lack of major sources of sulphur supply.

Sulphur

There are sizeable iron and cupreous pyrites deposits in the Urals, the Caucasus Mountains, the Altai Mountains in Siberia, in the Kirghiz mountain ranges and in Central Siberia. Production of pyrites—19,000 tons in 1913—rose to 142,000 tons in 1929, was 672,000 tons in 1933, and by the outbreak of war had reached one million tons a year. Pyrites reserves, however, are now said to be declining and production is falling.

Native sulphur is found in the Kara-Kum Desert, 250 miles east of the Caspian Sea, also near Kuibyschev and on the Kerch peninsula. There are, altogether, about 15 sulphur mines, and it is estimated that production of elemental sulphur, which was 80,000 tons a year before the war, has now risen to about 100,000 tons a year. One of the earliest sources of elemental sulphur was the treatment of copper pyrites by the Orkla process, which is known to have been used since the mid-thirties at several large copper smelting works. One of the most important is at Bljawa, in the south Urals, where output is about 15,000 tons a year.

An important factor undoubtedly contributing to the recent increase in elemental sulphur is the production from mirabilite (hydrated sodium sulphate), which is obtained from the Caspian Sea and treated at the recently opened Kara-Bogas combine. The process involves the reduction of mirabilite with carbon to yield sodium sulphide. This is then treated with acid to produce hydrogen sulphide, from which elemental sulphur is recovered by one of the many conventional methods.

Other sources of sulphur are receiving attention. These include recovery in the form of sulphuric acid from non-ferrous smelter gases. Coke oven gases and gases obtained from underground gasification of coal, which has been practised on a large scale for some years, are also used as a source of by-product sulphur or sulphuric acid. Interest is also being shown in other sulphurous raw materials, such as coal pyrites, in which there are about 2,000 million tons of sulphur in the Donetz Basin, pyrrhotite, gypsum and anhydrite. An account of the researches carried out in the U.S.S.R. into sulphur and sulphuric acid production from coal pyrites and anhydrite was given in *Quarterly Bulletin* No. 4, pp. 54-55.

Russia has also one of the world's largest sources of natural gas, and some of the output from " sour " wells is being treated to recover sulphur on a moderate scale. The distillation of oil shale, which is being carried out on a large scale in Estonia, is also being considered as a potential source of recovered sulphur.

Elemental sulphur, none of which is used in sulphuric acid production, is primarily required for the manufacture of rayon and staple fibre, rubber vulcanisation and, increasingly, agriculture.

The output of rayon and staple fibre — approximately 75,000 tons in 1950 — is planned this year at 350,000 tons. Three new rayon and staple fibre works have recently been built at Stalingrad, Kamensk and Kalinin, and among the more important of the old-established plants are those at Ugreshskoje, Gorki, Tambov, Molotov, Krassnodar, Tsherkassy, Ssinarskaja and Kolomna.

Sulphuric Acid

The production of sulphuric acid occurs mainly in superphosphate works, chemical and chemico-metallurgical combines scattered all over the country, but particularly with European centres in the north-west, in the Urals, in the Ukraine, and also in Western Siberia. Most of the sulphuric acid production arose, until recently, from pyrites. Smelter gases are now, however, increasingly used, and most new non-ferrous smelters incorporate a sulphuric acid plant.

One of the larger single enterprises is the gypsum acid plant built by I.G. Farben, which was dismantled by the Russians in Eastern Germany in 1946 and taken to the U.S.S.R. This has an annual output of 150,000 tons.

Total production of sulphuric acid, which increased sevenfold between 1913 and 1940, rose from 1.5 millions tons in 1941 to over three million tons in 1951, and is now about 3.5 million tons. The principal user of sulphuric acid is the fertiliser industry, which consumes about 60% of the total acid output. Ammonium sulphate is almost exclusively manufactured as a by-product at coking plants, and an output of 540,000 tons has been planned for 1955. This represents about 15% of the total nitrogen production for fertiliser use.

The output of phosphate fertilisers, of which about two-thirds is in the form of single and triple superphosphate, was 1.5 million tons (0.3 million tons P_2O_5) in 1940, but failed by 300,000 tons to reach its planned production target of three million tons in 1950, and was down to 2.6 million tons in 1953. Five million tons (one million tons P_2O_5) are planned for 1955, though the indications are that this target will not be reached.

New superphosphate plants are being sited mainly in agricultural districts, rather than near sources of raw materials. The expansion of fertiliser capacity since 1939 has been partly the result of requisition and partly of new construction. When Russia occupied the Baltic States and Eastern Poland, they took over three superphosphate plants at Riga, Memel and Lvov. During the war four new plants were built in Central Asia, and since the war, three additional works, at Kirovakan (Armenia), in Estonia, and in the Ukraine have been constructed. The plant in Estonia is being developed on an unusually large scale.

The balance of the country's sulphuric acid output is taken up by the metallurgical, petroleum chemical and textile industries.

Conclusion

The current level of output and consumption of sulphur in all forms is about 1.5 million tons a year. This tonnage represents about 16lb. per head of population, compared with a consumption of 73lb. in the U.S.A. and 47lb. in the United Kingdom. There have been no significant imports of elemental sulphur since the nineteen-thirties, and pyrite imports, mainly from Scandinavia, have been sporadic. Exports of elemental sulphur which were confined exclusively to the satellite states took place between the years 1949-1951 and are now believed to have ceased.

The lack of major sources of sulphur — sulphur domes or extensive rock sulphur deposits — which would allow large-scale production of elemental sulphur, necessitate the use of other sources of sulphur supply to meet the country's growing needs. Under the prevailing policy, aimed at the highest possible degree of self-sufficiency, sulphur must be procured regardless of cost or economic consideration. The recovery of sulphur from hydrated sodium sulphate — an expensive and time-consuming process — is indicative of this costly independence.

ELEMENTAL SULPHUR IN JAPAN

Production

OUTPUT of sulphur in 1954 totalled 185,653 metric tons, 2% less than during the previous year, and 7,000 tons short of the industry's production target. Compared with thirty-six producers in 1953, only twenty-eight contributed to the above totals, as follows :—

Producers :	*1954*	*1953*
	(000 metric tons)	
Matsuo Mining Co., Ltd. ...	57.1	61.4
Hokkaido Sulphur Co., Ltd. ...	27.4	24.4
Nihon-Tokushu Mining Co., Ltd.	17.6	12.0
Teikoku Sulphur Co., Ltd. ...	15.8	14.0
Shirane Sulphur Co., Ltd. ...	10.8	8.6
Nihon-Ryutetsu Co., Ltd. ...	9.4	8.3
Zao Mining Co., Ltd.	8.7	No data
Others	38.9	60.8
Total ...	185.7	189.5

Consumption

The largest, Matsuo Mining Company, are installing a modern sulphur ore refining plant, which is expected to be in operation by the end of July, 1955, and should result in increased output at lower cost.

Elemental sulphur consumption in 1954 totalled 180,068 metric tons, 4½% more than in 1953. The increase is accounted for mainly by greater requirements of carbon disulphide by the Japanese rayon industry, which rose by over 17%.

Consumption for :	*1954*	*1953*
	(000 metric tons)	
Carbon disulphide	94.4	80.5
Pulp	73.7	72.2
Agriculture	3.5	3.7
Other uses	8.5	16.5
Total ...	180.1	172.4

Exports and Developments

Exports in 1954 totalled 7,201 tons, compared with 13,000 tons in 1953, almost exclusively to Australia. Exporting at world price levels, Japanese producers are obliged, due to excessive production costs, to subsidise exports by their domestic sales to the extent of about 40%. Rising domestic demand, notably to meet the requirements of the rayon industry, one of Japan's principal exporters, and a keen desire to recapture a major share of the Far Eastern export market of sulphur, are causing the larger producers to give serious consideration to the necessity of installing economic refining plants. So far only Matsuo Mining Company and the Musa Mining Company, who are installing a Masobello plant, have taken action. Shortage of capital resources is, however, a major obstacle to rapid development on these lines.

The Desulphurisation of Coke Oven Gas by the Collin Process

General

THE Collin Process for the desulphurisation of coke oven gas was installed in 1952 on the coke oven plant at the iron and steel works of Messrs. Stewarts and Lloyds, Limited, at Corby, Northamptonshire. The plant operates in conjunction with a Chemiebau wet-contact sulphuric acid plant which converts the recovered hydrogen sulphide to sulphuric acid of 60° Bé strength.

The Collin Process is of the absorption-desorption type and its special features are :—

(a) The use of a dilute solution of ammonia as the desulphurising medium.
(b) Spraying the washing liquor through specially-designed nozzles in unpacked towers in a number of stages.
(c) The achievement of selective absorption from the gas of hydrogen sulphide relative to carbon dioxide.
(d) The cylic character of the process.

A brief description of the plant and process illustrated by the flow diagrams in Fig. 6 is given as installed at Corby and reference is also made to developments and modifications incorporated in new plants which have recently been built in Germany by F. J. Collin A-G.

Operation

In the desulphurising plant the coke oven gas cooled to 20°C is scrubbed with a solution of ammonia to recover hydrogen sulphide as ammonium sulphide. The solution of ammonium sulphide is then dissociated by heating, the hydrogen sulphide being evolved and the ammonia solution returned for further gas desulphurisation. The hydrogen sulphide is passed to the acid plant where it is burned in a waste heat boiler to give sulphur dioxide. This is then oxidised over a vanadium catalyst to give sulphur trioxide which is absorbed to give sulphuric acid.

Scrubbing is carried out in two unpacked tower washers, each divided into three stages. The ammonia solution is sprayed into the gas stream in each stage in turn through specially-designed nozzles counter-current to the gas flow. The height of the stages is such that the liquor spray persists throughout the whole height and does not collect as a liquid film on the walls of the washer. By this means intimate and controlled time of contact between gas and liquid is achieved, a condition essential for the selective absorption of hydrogen sulphide. The concentration of the ammonia solution is

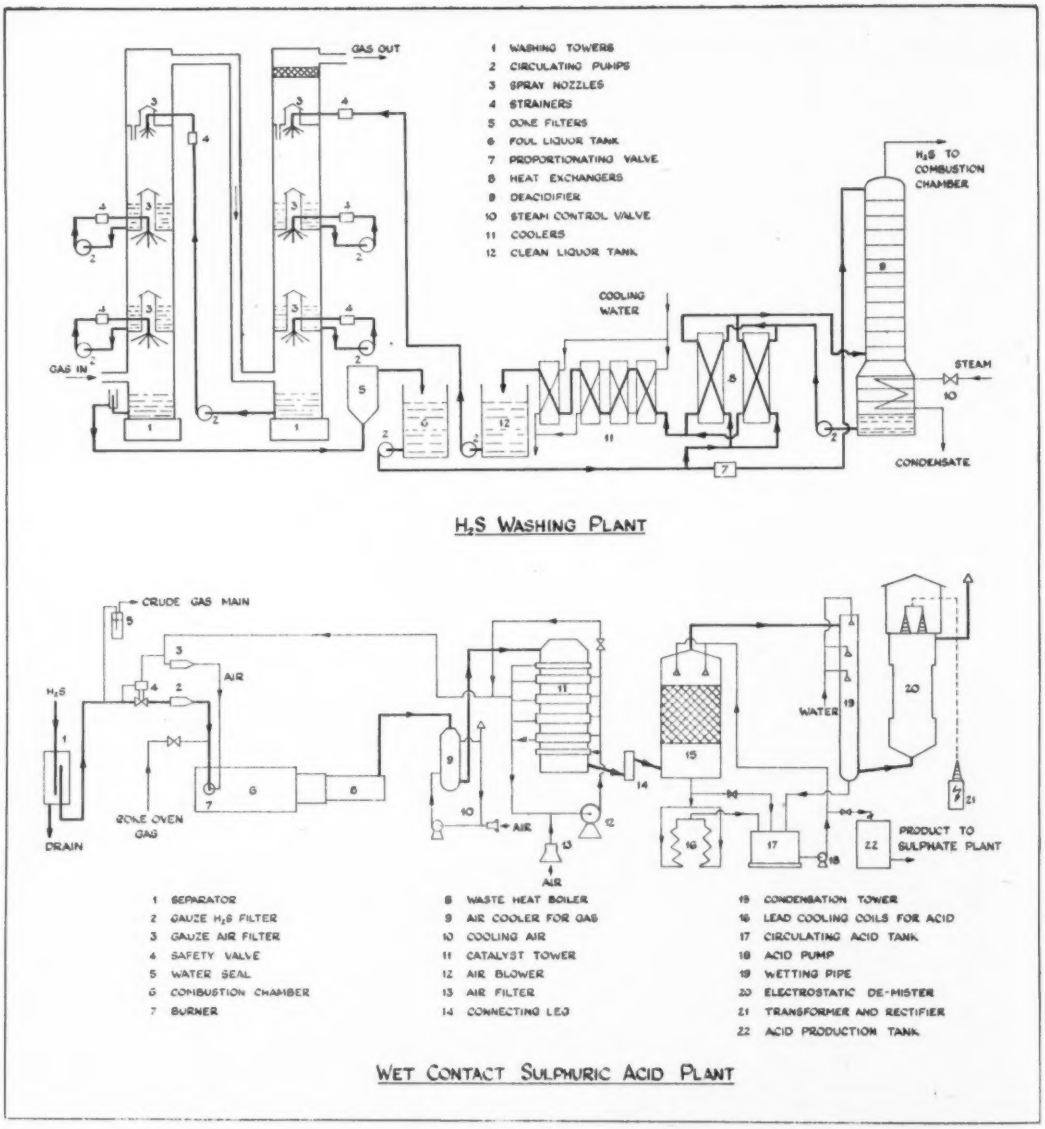


Fig. 6

usually about 1.5% depending on the ammonia content of the gas, with which it attains equilibrium.

As the scrubbing towers contain no packing materials the pressure drop through them is small, being 3-4 in. W.G., and thus no appreciable extra load is imposed on the exhausters.

The ammonia solution after being sprayed in turn through each of the washing stages, and having taken up hydrogen sulphide and some hydrogen cyanide and carbon dioxide, passes through a coke filter to a storage tank. It is pumped from the storage tank and split into two portions. About three-quarters of the whole passes through a heat exchanger, where it is

heated by hot regenerated ammonia liquor returning for re-use, and thence to the base of a stripping column. There it is heated by steam coils and the acid gases evolved.

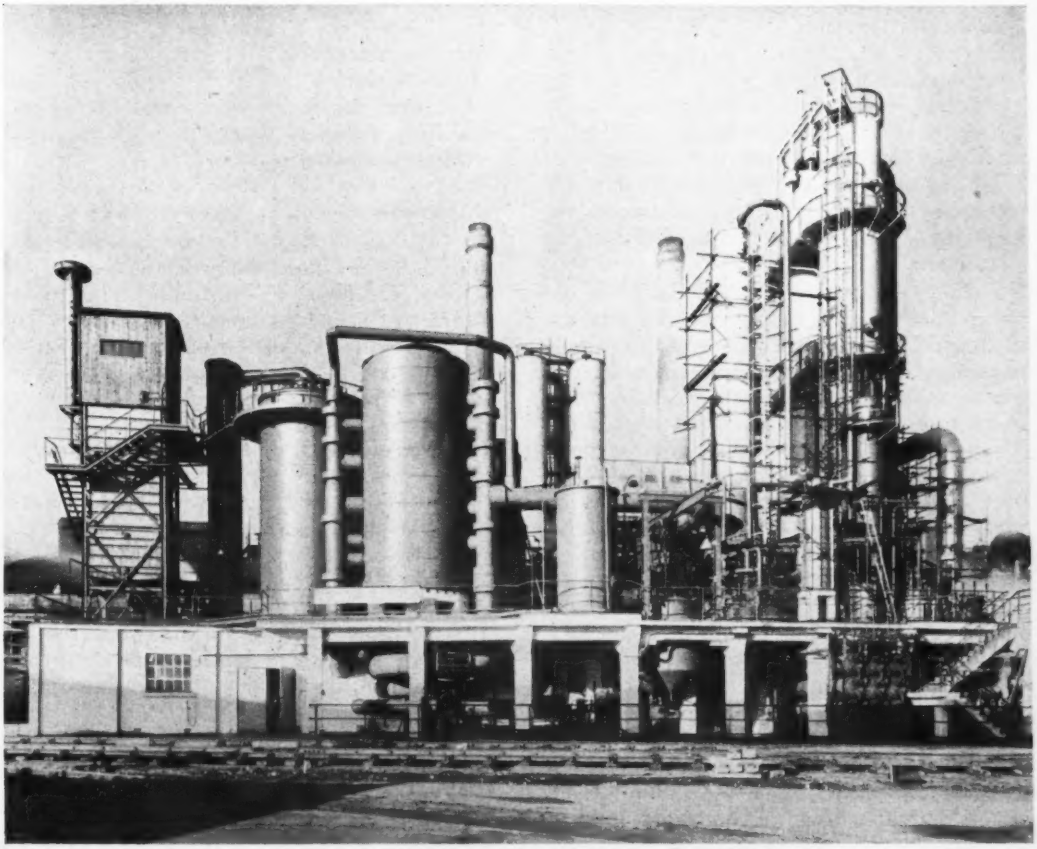
The remaining portion of fouled liquor is pumped to the top of the stripping column where it acts as cold reflux for the ascending gases and is itself stripped of acid gases. The temperature at the top of the column should be maintained between 25 and 30°C to prevent loss of ammonia from the stripping liquor.

The hot regenerated ammonia solution passes back through the heat exchanger and a cooler to a storage tank from which it is pumped for further scrubbing.

The acid gases from the stripping column are burned with excess air in a waste heat boiler.

The mixture of sulphur dioxide and excess air from the boiler is cooled, if necessary, by a small regulating cooler to 400-430°C, and then passes to the vanadium catalyst tower. There the sulphur dioxide is oxidised to trioxide, the heat of reaction being dissipated by external air cooling. Some of the heated air is used as combustion air, the remainder being recycled to mix with cold air for the controlled cooling of the catalyst layers.

The sulphur trioxide passes from the catalyst tower to the absorption tower which is packed with acid-resisting stoneware rings.



General view of the Collin plant at Corby.

60° Bé sulphuric acid is sprayed into the tower to absorb the sulphur trioxide. Any sulphur trioxide not absorbed passes through a humidifier column where some water is added as a fine spray, and the resulting sulphuric acid mist removed by electrostatic precipitation.

The strength of the final acid is controlled at 60° Bé by the amount of water added in the humidifier column. The outlet acid from the absorption tower, after cooling in water-sprayed lead spiral coils, is circulated for further absorption and periodically some is drawn off to the acid production tank. Although at Corby the hydrogen sulphide recovered in the Collin desulphurising plant is converted into sulphuric acid, it could of course, if preferred, be burnt in a modern type Claus kiln to produce elemental sulphur.

Further Developments

The Corby plant, incorporating gas desulphurising and acid manufacture, was the first of its type and size to be erected by the Collin Co., and operating experience on this plant led to further development and modification of the process. Progress in this respect centred round the construction of the hydrogen sulphide washer and the design of the deacidifier.

Fig. 7 illustrates the latest design of the Collin desulphurising plant. In this system the deacidified liquor is first pumped to the nozzle of the upper washing stage where it collects in the sump of this stage and runs through an overflow to the sump of the next stage, from which it is pumped to the nozzle of the same stage. This means that the liquor is sprayed back into the same sump from which it is withdrawn by the stage pump. It also ensures that the liquor flowing from stage to stage is preferably fed to the pump of the next stage before mixing with the liquor already circulating therein, thus always maintaining a favourable difference in concentration.

The modifications to the deacidifier involve the use of indirectly steam-heated tube heaters made of aluminium which are arranged outside the deacidifier. The heaters are of the thermo-syphon type which promote circulation of the liquor from the sump of the deacidifier through the thermo-syphon and thence back to the base of the deacidifier.

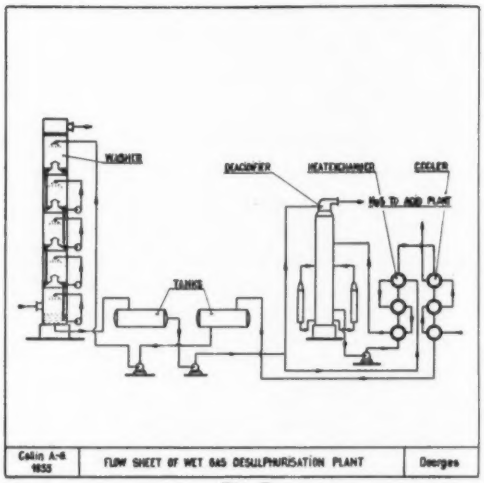


Fig. 7

Aluminium is now used in Germany for the manufacture of the deacidifier and the heat exchangers. At Corby aluminium heat exchangers and heating coils have been in use for 2½ years and the deacidifier is constructed of chemical stoneware.

Economics

It is claimed that the new system readily affords 80-85% desulphurisation of the gas. At Corby, depending on conditions at the plant, 70-75% desulphurisation is achieved. The average daily production of acid is about 30 tons of 60° Bé sulphuric acid, which is used in the by-product plant for the manufacture of ammonium sulphate.

For every ton of acid produced, approximately one ton of steam is generated in the waste heat boiler. This steam could, if necessary, be used for heating the deacidifier.

The economic aspects of the process are determined by a number of factors. Features favourable to the process are the facts that all the materials required for the production of sulphuric acid are contained in the coke oven gas and that the manning of the plant requires only two operators per shift. On the other hand the coke oven gas must contain an adequate concentration of hydrogen sulphide and in this respect a minimum concentration of 300 to 350 grains H_2S/100 cu. ft. of gas is essential. Furthermore, the volume of coke oven gas available for treatment should be

sufficient to permit a daily production of about 15 tons of 60° Bé sulphuric acid. Obviously, for a gas containing a higher concentration of hydrogen sulphide, say of the order of 500-600 grains/100 cu. ft., a correspondingly smaller volume of gas can be treated economically.

Ultimately the merits of the process must be assessed in the light of local conditions, such as the cost of transport and handling, which determines the comparable cost of acid purchased from outside sources. Acid production in the Collin plant at the Corby works, even after allowing for capital charges, is appreciably more economical.

We are indebted to Mr. T. H. Williams, Manager, Chemical Research Department, Stewart and Lloyds, Ltd., for the detailed information placed at our disposal.

The Elliott-Ludlow Process (Patented)

THIS process, which is being promoted by Associated Engineers, Ltd., of Calcutta (see *Quarterly Bulletin* No. 7, p.61), is said to be capable of producing pure sulphur from crude ores or concentrates quickly, economically and in a relatively simple plant.

The essential features of the process are the separation of sulphur from the gangue by boiling in a saline solution, and the action of the rising water vapour which lifts the molten sulphur globules to the surface. Calcium chloride has been found to be the most suitable reagent, being comparatively cheap, economical and non-corrosive.

Operation

This is diagrammatically shown in the flowsheet in Fig. 8. The ore is crushed to about 10 mesh screen size. It is then mixed and heated in an aqueous solution containing 85% wt/vol. calcium chloride to a temperature of about 120°-130°C, i.e. slightly below the boiling point of calcium chloride. The rising water vapour bubbles bring the sulphur to the surface in the form of molten globules, and this effect is greatly increased if the heating is taking place in a vessel with a fixed baffle, which produces a venturi-like throat and increases the pressure upwards. The solution is then filtered,

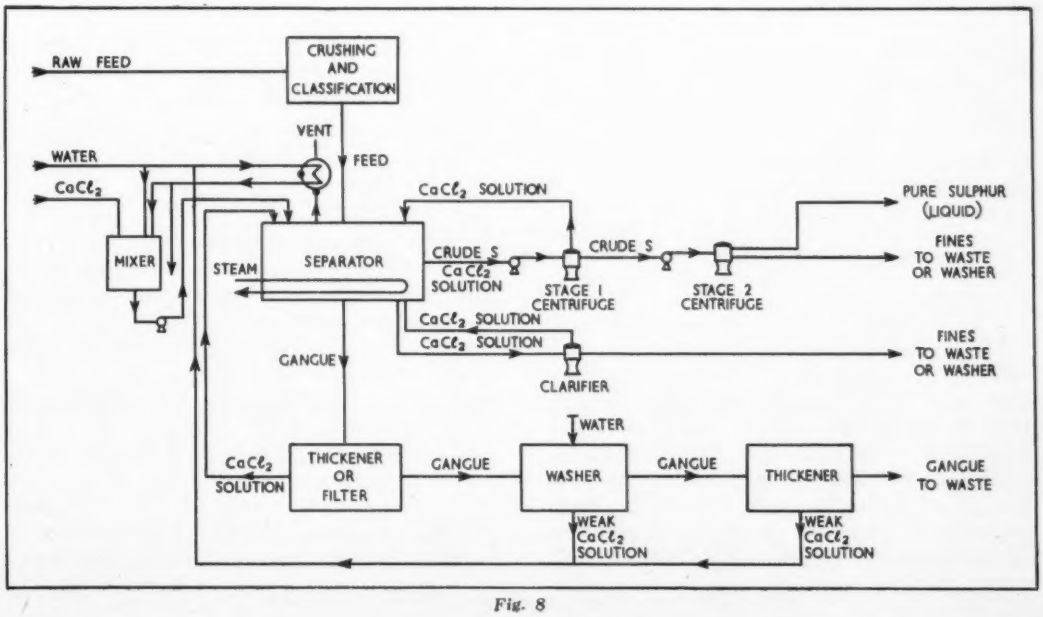


Fig. 8

the solids seperate out, and the molten sulphur is afterwards separated from the calcium chloride solution by gravity settling or centrifuging. The gangue is subsequently washed to recover calcium chloride and heat. Finer grinding of the ore would result in slightly improved recovery but the additional cost would only justify this in special instances.

Initial small-scale experiments indicate the following sulphur balance :

	Ores containing :	
	42-44% S	*36-38% S*
Recovery	85-89%	74-78%
Sulphur purity	99.75%	99.15%
Sulphur content of gangue	2.89%	2.84%

The process is suitable for crude ores of 40% sulphur content and over, whereas lower grade material needs beneficiation by flotation. This process is particularly suitable for refining ores of volcanic origin but those containing limestone gangue can also be treated successfully, though this will require a slightly increased concentration of calcium chloride in the solution and thus raise consumption of the reagent. Acidic ores can also be treated if neutralised with lime.

Requirements and Cost

It has been estimated that to recover one ton of sulphur the requirements would be as follows :—

Reagent — Calcium Chloride	50 lb.
Fuel (if no heat recovery is effected)	66 lb. fuel oil or 1,600 cu. ft. gas
Electric Power (crushing) ...	25 kWh.

It has been stated by Mr. Elliott that plant costs should be low. At present the promoters are in touch with various plant manufacturers and it is expected that full details of construction costs may be available later this year. On the basis of present plans, which provide for batch operations involving relatively high cost of labour, it is estimated that production costs, including an allowance for amortisation, will be about £6-8 per ton of refined sulphur. Investigations are in hand to make the sequence of operations semi- or fully automatic.

It is reported that the Indian Geological Survey has expressed great interest in the process, with particular reference to the newly-discovered sulphur deposit at Ladakh in Kashmir. At the same time, the method is arousing interest among plant manufacturers and potential users in several countries.

Recovery of Elemental Sulphur from Pyrite and Pyrrhotite*

A RESEARCH project started at the Mines Branch, Ottowa, in 1951, to explore the possibilities of obtaining sulphur from sulphide minerals, has resulted in the development of a process for recovering elemental sulphur directly from pyrrhotite, and also from the artificial pyrrhotite obtained when pyrite is thermally decomposed, and the labile atom of sulphur removed.

The Process

The method consists of the controlled oxidation, by oxygen or air under pressure, of an aqueous suspension of finely-ground pyrrhotite in an autoclave. The principal reaction, which is exothermic, and produces about 1,550 B.t.u.'s per lb. of pyrrhotite oxidised, liberates sulphur directly and simultaneously forms a finely-divided ferrous oxide containing about 4% sulphur. The most favourable temperature for the process is between 110°C and 125°C. When the temperature of the autoclave is above the melting point of sulphur (about 120°C for the monoclinic form) the latter agglomerates into globules which, on cooling, solidify into nodules. These nodules are readilly separated from the ferric oxide by passing the contents of the autoclave over a screen.

Principal Features of the Process

Only sulphur combined as pyrrhotite is converted to elemental sulphur and iron oxide ; pyrite, if present in the pyrrhotite, is oxidised almost entirely to iron sulphate and sulphuric acid. Other sulphides are oxidised to their sulphates, completely or partly according to their reactivity.

An important feature of the process, which tends to free the ferric oxide from contaminating elements, is the tendency of molten sulphur to occlude sulphides in preference to oxides. If unleached sulphides are present in

*—We are indebted to K. W. Downes for the information which he and R. W. Bruce presented in a paper to the Canadian Institute of Mining and Metalurgy at Toronto, in April, 1955.

the autoclave when the reaction is stopped, a marked concentration of these sulphides is found in the sulphur nodules, which, if ground and tabled, permit the separation of metal values in the table sand and the sulphur in the table slime.

Recovery of Sulphur

Using oxygen, sulphur recovery up to 80% has been obtained from pyrrhotite flotation concentrates at 150lb./sq. in. during an oxidising period of 1½ hours at 110°C, but at an oxidising pressure of 30lb./sq. in., the sulphur recovery was only about 62 per cent. Recovery from artificial pyrrhotite, obtained by thermal decomposition of very pure pyrite, was as high as 85 per cent, with 150lb./sq. in. of oxygen.

Experiments have shown that re-cycling the autoclave liquor can considerably reduce the amount of sulphur oxidised to sulphate.

Base Metal Recovery

Tests show that it may be possible to recover a number of base metals from pyrite and pyrrhotite ores during the process, by the metal content of the ores being oxidised to their sulphates and recovered in the autoclave liquor. Nickel and lead reacted most favourably in this way. The results with copper and zinc were not so satisfactory.

Future Application

The process, so far developed only to the laboratory stage, clearly holds great promise and in the case of Canada is of particular importance in view of the abundance of pyrites, pyrrhotite and other metal sulphide ore deposits and the large demand for brimstone. The economics of its commercial development and application are now being investigated.

Current Events

UNITED KINGDOM

Simon-Carves, Ltd.—New Acid Plants

In the recently-published *Simon Magazine* the company's contribution to the new construction programme of the United Kingdom acid industry is outlined.

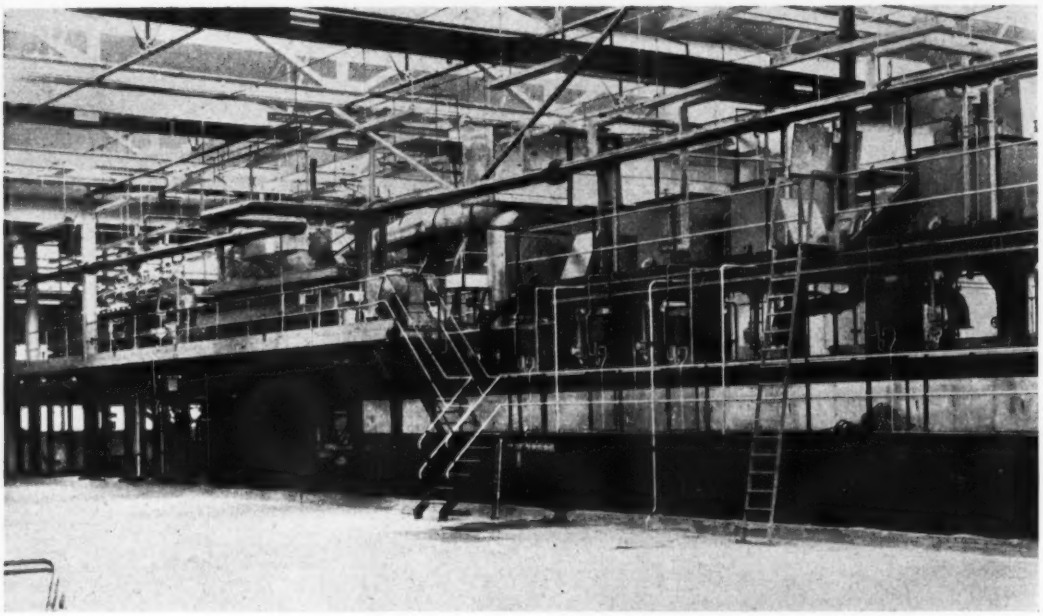
It is estimated that plants built by Simon-Carves, Ltd., account for about 85% of the total new sulphuric acid production capacity from pyrites installed during the last four or five years, and about 75% of the new anhydrite capacity which will be available by the end of 1955. In the review of the sulphur industry of the United Kingdom (*Quarterly Bulletin* No. 8, p.11) ten new pyrites-roasting plants, with an aggregate consumption capacity of 421,000 tons pyrites, are listed. Of these, six were built by Simon-Carves, Ltd., and a seventh by their subsidiary, Huntingdon, Heberlein & Co., Ltd. These seven plants account for 65% of the above total. The two companies have also, in fact, been responsible between them for all the flash roasting plants built in the United Kingdom for acid production from pyrites. Simon-Carves, Ltd., are also constructing two Kachkaroff plants for the production of sulphuric acid from spent oxide, and these are nearing completion. One is for the South-Eastern Gas Board at Phoenix Wharf, London, and the other is for the National Coal Board East Midlands Division near Chesterfield.

The company's activities abroad have resulted in their securing important contracts for acid plant construction. These include the following works, each of which propose to use elemental sulphur as the raw material.

Company	*Annual Acidmaking Capacity (tons)*
The East Coast Farmers' Fertiliser Co., Ltd., New Zealand ...	40,000
Burmah Oil Co. (India Trading), Ltd., India	3,500
Century Rayon, India	7,000
Quimica Industrial de Monterrey, S.A. Mexico	9,000
Indian Iron & Steel Co., Ltd., India	21,000
Eerste Nederlandsche Cooperatieve Kunstmestfabriek, Holland ...	40,000
Imperial Chemical Industries, Ltd., India	3,500
Challenge Phosphate Co., Ltd., New Zealand	40,000

Courtaulds Limited's Viscose Research Laboratory

The new viscose research laboratory of Courtaulds, Ltd., and its pilot plant buildings, have recently been completed. The largest of the company's six research laboratories, it is concerned almost entirely with the manufacture of fibres by the viscose process. Among notable



Viscose research laboratory of Courtaulds Ltd., at Coventry. Pilot plant for viscose rayon staple production.

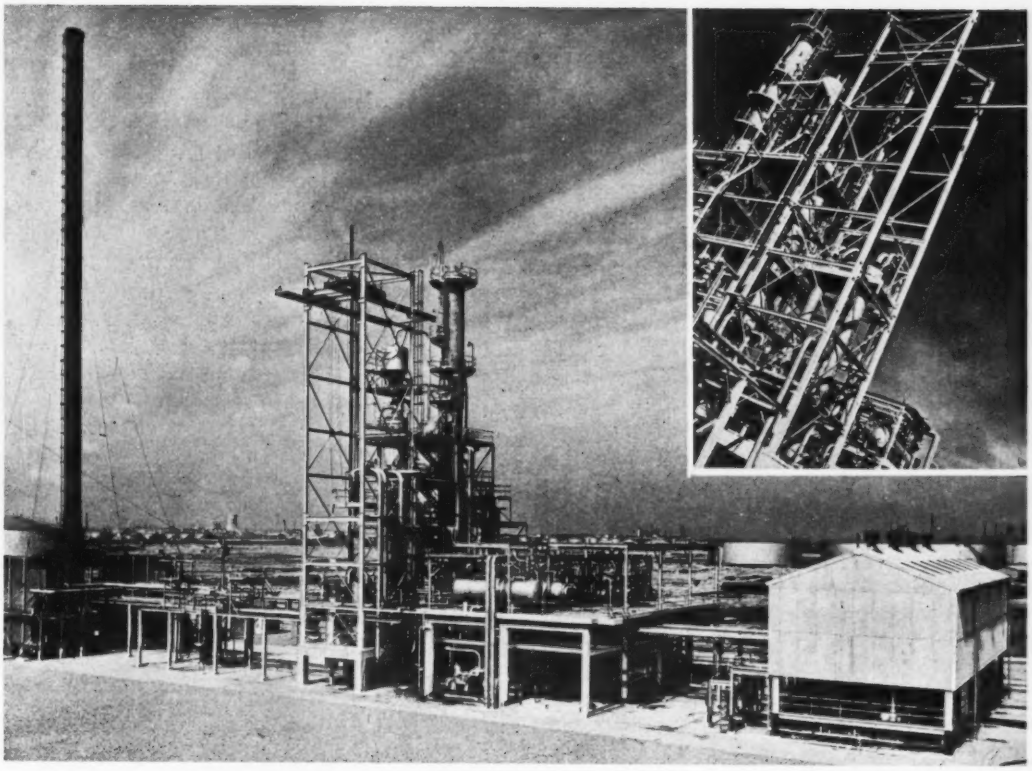
exhibits shown at the recent Open Day at the laboratory were an apparatus which studies the course of the reaction of alkali cellulose with carbon disulphide to form cellulose xanthate ; and phase diagrams illustrating the regeneration of viscose rayon in an aqueous solution of sulphuric acid, sodium sulphate and zinc sulphate.

Courtaulds, Ltd., are the largest consumers of regular sulphur, and amongst the largest sulphuric acid manufacturers in the United Kingdom.

Hydrodesulphurisation Plant at Shell Oil Refinery, Stanlow

The hydrogen desulphurisation plant installed at the oil refinery of the Shell Petroleum Company at Stanlow, Cheshire, came into full production in April. The first of its kind in the world, the £1-million plant has been designed to extract the sulphur content from light gas oil and light catalytically cracked cycle oil. The extraction process is based on the " trickle " technique, whereby the oil is made to trickle over a highly selective catalyst in a hydrogenated atmosphere. The hydrogen converts the sulphur into hydrogen sulphide, which is separated from the oil and is then itself converted to elemental sulphur. Two outstanding features of the trickle technique are the high degree of desulphurisation with a relatively small amount of hydrogen gas, and that, even while using this low hydrogen recycle, the catalyst remains unimpaired. These conditions result in a considerable saving in operating and capital costs, power consumption, and the area over which heat transfer is required.

The current throughput of the plant is about 7,000 barrels a day of light, catalytically cracked cycle oil, and desulphurisation of more than 90% is being obtained. On the basis of its original sulphur content of about 2.9%, it is estimated that 9,000 tons of sulphur annually will be recovered in this way at the Stanlow Refinery.



General view of the new hydrodesulphuriser at the Shell Refinery, Stanlow, with (inset) close-up of main fractionator.

CANADA

New Acid Plant

As the result of the imminent large-scale expansion of uranium ore production in the Blind River area in Northern Ontario, the need for a major source of sulphuric acid supply has arisen in order that producers may be able to leach ore output in situ.

Algom Uranium Mines, in which the Rio Tinto Company, Ltd., of London, have recently acquired a major share, expect an annual consumption of at least 110,000 tons acid, and the needs of Consolidated Denison Mines, the second largest uranium ore producer in the area, are also expected to be considerable.

To meet the anticipated requirements of 110,000-150,000 tons per annum, the following alternative proposals* were under consideration :—

(i) A new acid plant to be built by Canadian Industries, Ltd., at Copper Cliff, 90 miles from Blind River, which would use smelter gases arising at the adjacent plant of the International Nickel Company, thus augmenting the existing combined plants which already produce 80,000 tons acid, and 90,000 tons liquid SO_2 per annum.

(ii) Noranda Mines, Ltd., to erect a plant at Blind River similar to that operating at Welland which, using pyrites concentrates, produces 18,000 tons brimstone and the equivalent of 36,000 tons sulphur, in the form of sulphur dioxide gas, which is converted to sulphuric acid in the adjacent plant of North American Cyanamid, Ltd.

(iii) Algom Uranium Mines to erect their own acid plant with a daily capacity of 330 tons, based on the use of brimstone.

*—According to an unconfirmed report the Noranda project has been adopted, and negotiations to erect a 500 t.p.d. acid plant on a 125-acre site at Cutler, 20 miles east of Blind River, have begun.

UNITED STATES

Shipping of Liquid Sulphur

The first shipping of liquid sulphur in large quantities over long distance water routes began on May 4th, when two of three new insulated barges started from Freeport Sulphur Company's docks at Port Sulphur, 45 miles south of New Orleans, with a cargo of sulphur piped direct from the mine. Their destination was the National Lead Company's titanium plant at St. Louis, 1,100 miles away.

The three barges, built by Ingalls Shipbuilding Corporation and operated by Coyle Lines Inc., are insulated with foam glass four inches thick, and are equipped with boilers and heating coils to maintain a minimum temperature of 260°F, 20 degrees above the melting point of sulphur. Coyle Lines became the first commercial carrier to transport liquid sulphur when, in 1952, they put into service a 1,000 ton barge operating between the Moss Bluff mine of Texas Gulf Sulphur Company and a sulphur consuming plant about 50 miles away. The barges have a carrying capacity of 2,500 tons of molten sulphur each.

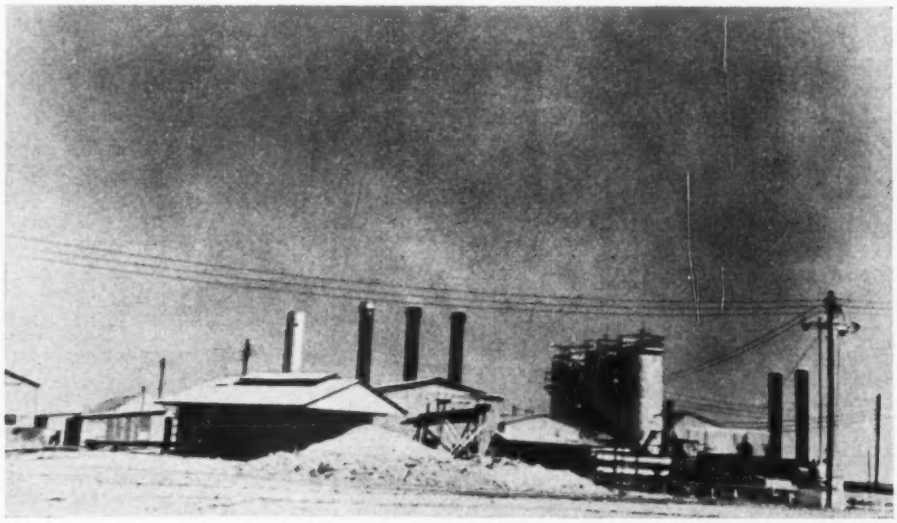
The National Lead Company are reported to have spent about $500,000 on receiving and storing facilities at their plant. These include a dock, bridge work for piping the sulphur, steam-jacketed unloading lines and two insulated, steam-heated storage tanks. In view of the saving gained by these advantages — elimination of dry sulphur storage, of storage losses which in the past averaged over 1%, of re-heating and melting before use, etc. — the expenditure is stated by a senior executive of the company to be well worth while. A number of acid makers receiving their supplies by river are now giving consideration to adapting their plant facilities to this novel and economic method of sulphur transport.

In the U.K., it will be recalled, the only transportation of liquid sulphur is undertaken by the Shell Petroleum Company who carry small quantities, by road, to the works of Messrs. Brotherton & Co., Ltd., nine miles away.

Standard Sulphur Company

The expansion of the company's Damon Mound plant was completed in January, and production there during the first four months of this year was about 40% greater than during the last four months of 1954. The company's Frasch sulphur output during 1954 amounted to about 50,000 tons.

Meanwhile, exploration work on Allen Dome, in Brazoria County, Texas (see *Quarterly Bulletin* No 7, p.57), continues. The company are also negotiating in respect of other salt domes on the Texas coast, and hope shortly to announce the location of their next plant.

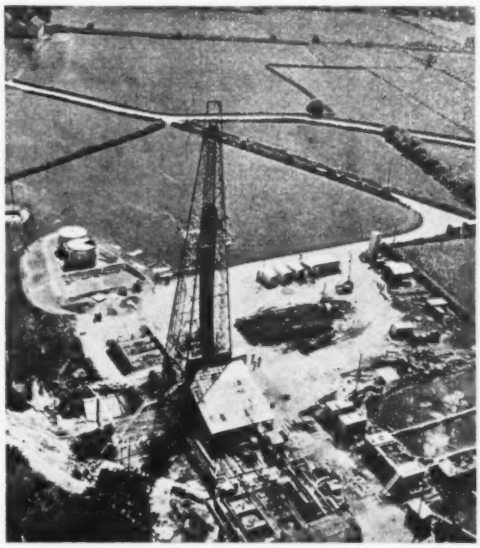


Damon Mound Sulphur Station No. 1

FRANCE

Sulphur from Natural Gas

The Société Nationale des Petroles d'Aquitaine have recently announced plans for the construction of a large-scale gas treatment plant at Lacq, 100 miles south of Bordeaux, in the Western Pyrenees, where vast reserves of



Drillings at Lacq, Western Pyrenees.

natural " sour " gas have been discovered. The gas, which contains 17.06% H_2S and 8.58% CO_2, is found at a depth of 10,000 feet below the surface. Development work is at present held up while special steels are being tested to provide suitable piping for the highly corrosive hot gas. The plant will have a daily treatment capacity of one million cubic metres of gas, and will incorporate a recovery unit with an annual capacity of 70,000 tons of sulphur. It is expected that output of clean gas and associated by-products (sulphur, high octane petrol, butane and propane) will start in 1957. At present the French industry annually consumes about 170,000 tons of elemental sulphur and about 400,000 tons of sulphur in domestic and imported pyrites.

ISRAEL

Fertilisers & Chemicals, Ltd., Haifa

The company's superphosphate plant is now reported to be working to full capacity for the home market. The first export order for 5,000 tons is being shipped to Cyprus and a number of others are being negotiated. During the last three months of 1954 production of superphosphates amounted to 24,050 tons, bringing the total output for the year to 76,562 tons, more than twice the total produced in 1953.

Sulphuric acid production in 1954 amounted to 43,928 tons and was 2½ times greater than in 1953. Acid exports to Turkey under the existing barter agreement were restricted due to the inability of the Turkish customers to take delivery. In consequence, the reciprocal shipments of Turkish pyrites had also to be reduced and the company's pyrites requirements were met by the import of 5,000 tons from Spain.

CHILE

Sulphur Production and Consumption — 1954

Output in 1954 of refined sulphur (minimum 99.5% pure) totalled 39,702 metric tons, compared with 32,793 metric tons in 1953. It originated from eight producers, of which Sociedad Azufrera " Aucanquilcha " continued to be the largest, accounting for 38% of total production.

Consumption of sulphur in 1954 totalled 25,300 tons, an increase of about 45% compared with the previous year, accounted for primarily by greater consumption in the rayon, steel and non-ferrous mineral industries. A new sulphuric acid plant is at present under construction, with an annual consumption capacity of 3,000 tons sulphur. It is due to be completed by the end of this year and will then cause annual " acid-sulphur " consumption to rise to 8,000 tons.

Expansion of Sulphuric Acid Capacity

A new sulphuric acid plant near Antofagasta, backed by the Corporacion de Fomento de la Produccion, is expected to start producing at the end of 1955, with an annual output of about 8,500 tons H_2SO_4. A smaller plant is also under construction by the government at Atacama. The plant installed last year by the 'Compania Minera y Comercial Sali Hochschild at Copiapo is now producing at a daily rate of 20 tons.

Statistical Appendix

WORLD PRODUCTION OF NATIVE AND RECOVERED SULPHUR (thousand tons)*

	1952	1953	1954
U.S.A.	5,546.5	5,535.3	5,920.0e
Canada	8.0	16.3	20.0e
Mexico	48.3	33.6	125.0e
Colombia	2.6	2.7	5.1
British West Indies	1.6	3.0	4.3
Ecuador	2.4	1.0	6.0e
Chile	49.9	33.3	39.1
Argentina	15.0	16.0	18.0e
Peru	5.1	4.5	4.0e
Bolivia (exports)	5.5	2.5	5.0e
U.K.	14.8	25.7	42.0e
France	15.3	10.9	4.0e
Belgium	0.4	0.2	1.0e
Holland	3.8	11.9	12.0e
Western Germany	51.1	59.6	65.0e
Spain	40.4	39.8	40.0e
Portugal	15.5	16.6	15.0e
Norway	103.1	101.7	100.0e
Sweden	17.5	23.8	25.0e
Italy (fused)	232.7	224.2	198.5
Turkey	8.2	9.7	9.9
Egypt...	3.1	3.3	4.0e
Iraq	0.6	5.0e	5.0e
Iran	1.5	1.0e	1.0e
Formosa	5.0	5.0	5.9
Japan	176.6	189.5	182.8
New Zealand	0.5	—	—
	6,374.8	6,376.1	6,857.6

e—Estimated, or pending confirmation in official statistics.

*—The undermentioned countries are not included, due to lack of official information, but it is estimated that production in 1954 was as follows :—

	Tons		*Tons*
U.S.S.R.	100,000	East Germany ...	75,000
Poland	2,000	China	5,000

U.S.A. PRODUCTION OF BY-PRODUCT SULPHURIC ACID

(short tons of 2,000lb. 100% H_2SO_4)

	Copper plants (a)	*Zinc plants (b)*	*Total*
1945-49 (average)	147,638	552,116	699,754
1950	131,342	609,571	740,913
1951	189,125	635,948	825,073
1952	202,364	664,714	867,078
1953	231,213	636,864	868,077
1954	273,725	612,250	885,975

(a) Includes acid produced at a lead smelter. Excludes acid made from pyrites concentrates in Montana and Tennessee.

(b) Excludes acid made from native sulphur, which, applicable to zinc plants only, amounted to 54,510 short tons in 1954.

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